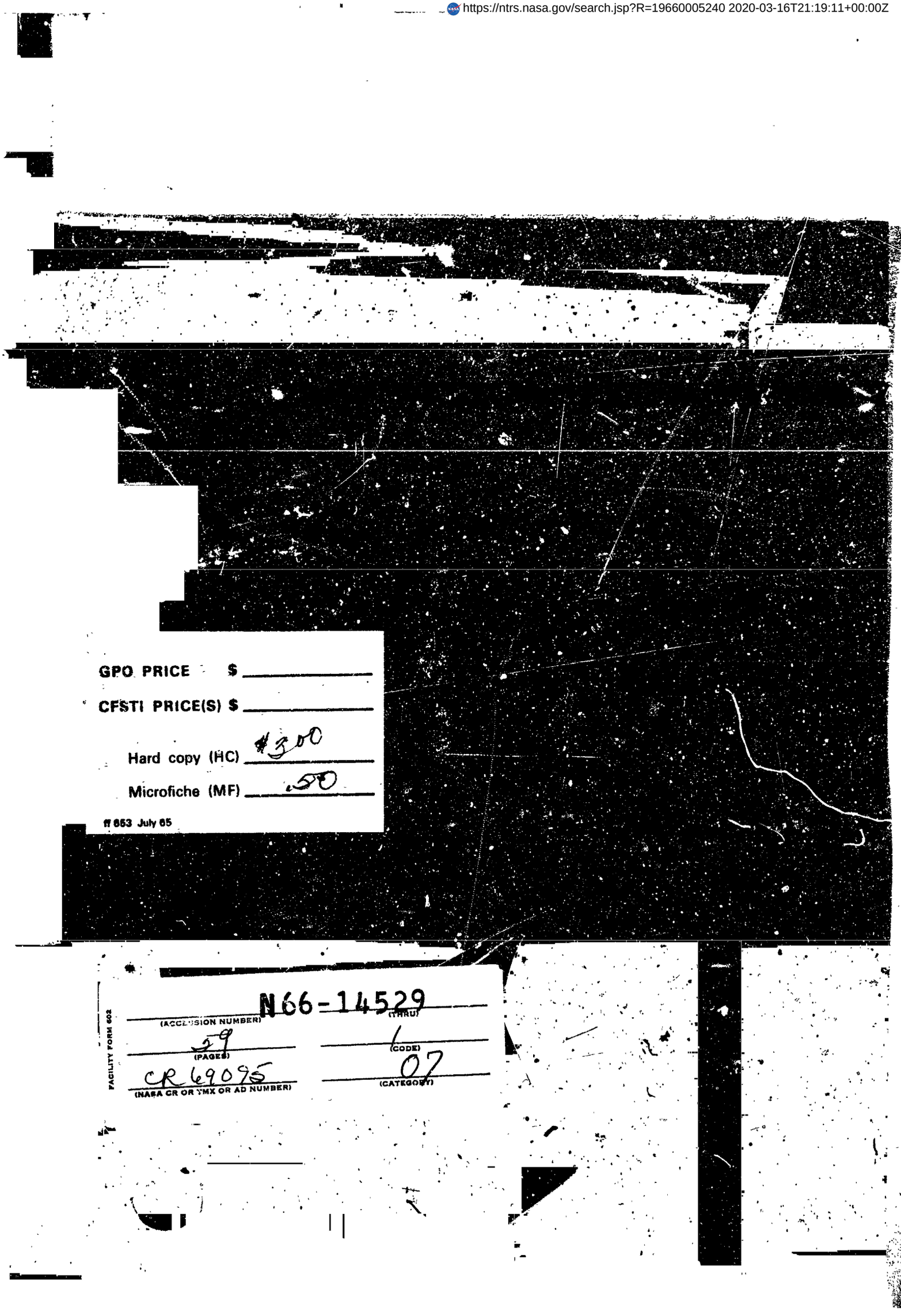

PHYSICAL SCIENCE LABORATORY

NEW MEXICO STATE UNIVERSITY

University Park, New Mexico

THE DESIGN AND PERFORMANCE

OF

MODEL 2.041 QUADRALOOP TELEMETRY ANTENNAS

FOR

THE NASA JAVELIN, FLIGHT 12.03

6 May 1964

Project Engineer: T. C. McConnell

Approved:
Supervisor
Electromagnetics Group — H. W. Haas
Senior Engineer

Contract No. NAS 5-3318

ABSTRACT

14529

The electrical characteristics of the Model 2.041 Quadraloop two element arrays used on the Javelin 12.03 are presented. One array is tuned to 231.4 Mc/sec and the other array is tuned to 240.2 Mc/sec. Both arrays are used for telemetry.

Impedance and radiation pattern data are presented when a Fiberglas nose cone is mounted over the antenna arrays.

Author

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LIST OF FIGURES

1.0 INTRODUCTION

The National Aeronautics and Space Administration at Goddard Space Flight Center requested the Physical Science Laboratory of New Mexico State University to develop two telemetry antenna systems for the Javelin 12.03. One system is to be tuned to 231.4 Mc/sec and the other system to be tuned to 240.2 Mc/sec. Both telemetry antenna systems will radiate primary data from lift-off to fourth stage burnout and secondary data from fourth stage burnout to reentry. During the primary data period, a Fiberglas nose cone will be in place over the payload where the antennas are to be mounted and during the secondary data period the Fiberglas nose cone will be removed and a probe will be erected. Radiation pattern measurements will be made to determine if the radiation level is high enough to obtain good telemetry data. This report describes the Model 2.041 Quadraloop which is used to meet the antenna system requirements.

2.0 ELECTRICAL CHARACTERISTICS

The design of the Model 2.041 Quadraloop Antenna (Fig. 1) has been discussed in another report.[1]

2.1 Impedance

2.1 1 Single Antenna Impedance

The impedance versus frequency curves of a single antenna for each of the fundamental frequencies are shown in Figs. 2 and 3.

2.1.2 Array Impedance

The impedance versus frequency curves for each array are shown on Figs. 4 and 5. As shown on the impedance curves the center frequency of each array is less than a 1.5:1 VSWR.

2.2 Array Harness and Array Phasing

The array harnesses and phasing for each antenna system are shown in Figs. 6 and 7.

The relative phase between antennas in an array is 180° where the low serial number antenna is 0° and on the end of the $\lambda/2$ cable.

2.3 Radiation Patterns

To determine effects on the radiation characteristics with and without Fiberglas cover, two sets of radiation patterns were measured with configurations shown in Figs. 8 and 9.

The 231.4 Mc/sec antenna array was connected to the transmitter and the rf power was received by an eight-turn right circular helix antenna.

Because the frequency difference between antenna systems is small, only the 231.4 Mc/sec array was measured.

A spherical coordinate system (Fig. 10) fixed with respect to the antenna is used to define the patterns.

The radiation patterns for the Javelin with the Fiberglas nose cone are shown in Figs. 11 through 29 and the power contour plot in Fig. 30.

The radiation patterns for the Javelin without the Fiberglas nose cone are shown in Figs. 31 through 49 and the power contour plot in Fig. 50.

2.4 Radio Frequency Breakdown

In Fig. 51 a curve is shown which is representative of the Model 2.041 Quadraloop. The data were obtained by testing a single antenna in a vacuum chamber in which ions were introduced. The curve shows the initiation and termination of breakdown as a function of altitude and power.

3.0 CONCLUSIONS

The Model 2.041 used as described above gives adequate coverage during the primary and secondary periods of data transmission. With the nose cone mounted the gain at $\theta = 180°$, $\phi = 0°$ is -3 db with respect to a Stoddart half-wave dipole. Without the nose cone and with a probe erected, the gain at $\theta = 180°$, $\phi = 0°$ is +3 db.

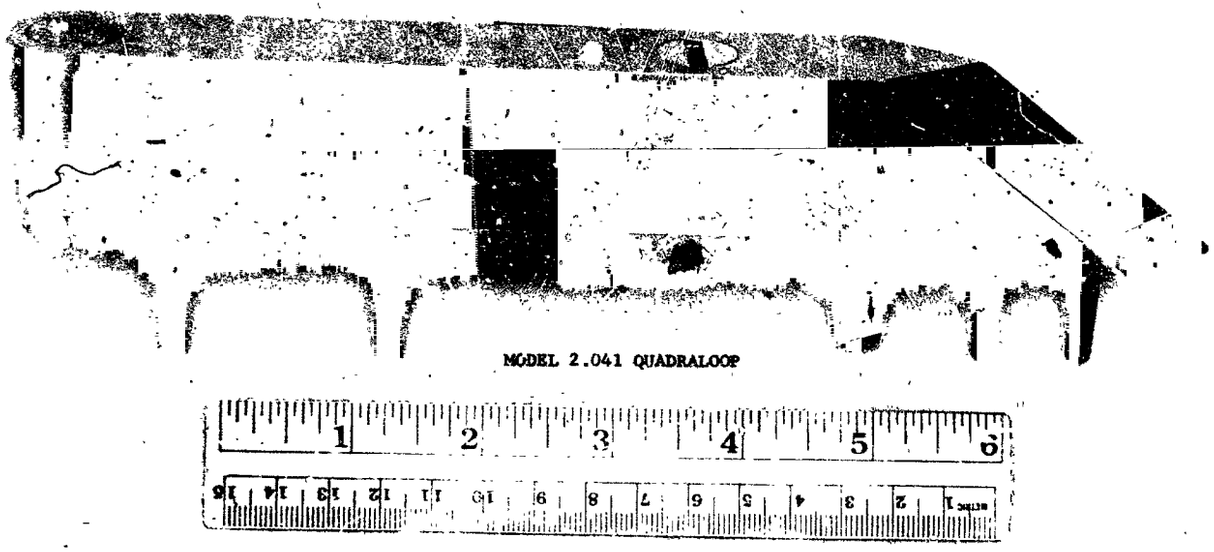


FIG. 1 - MODEL 2.041 QUADRALOOP ANTENNA

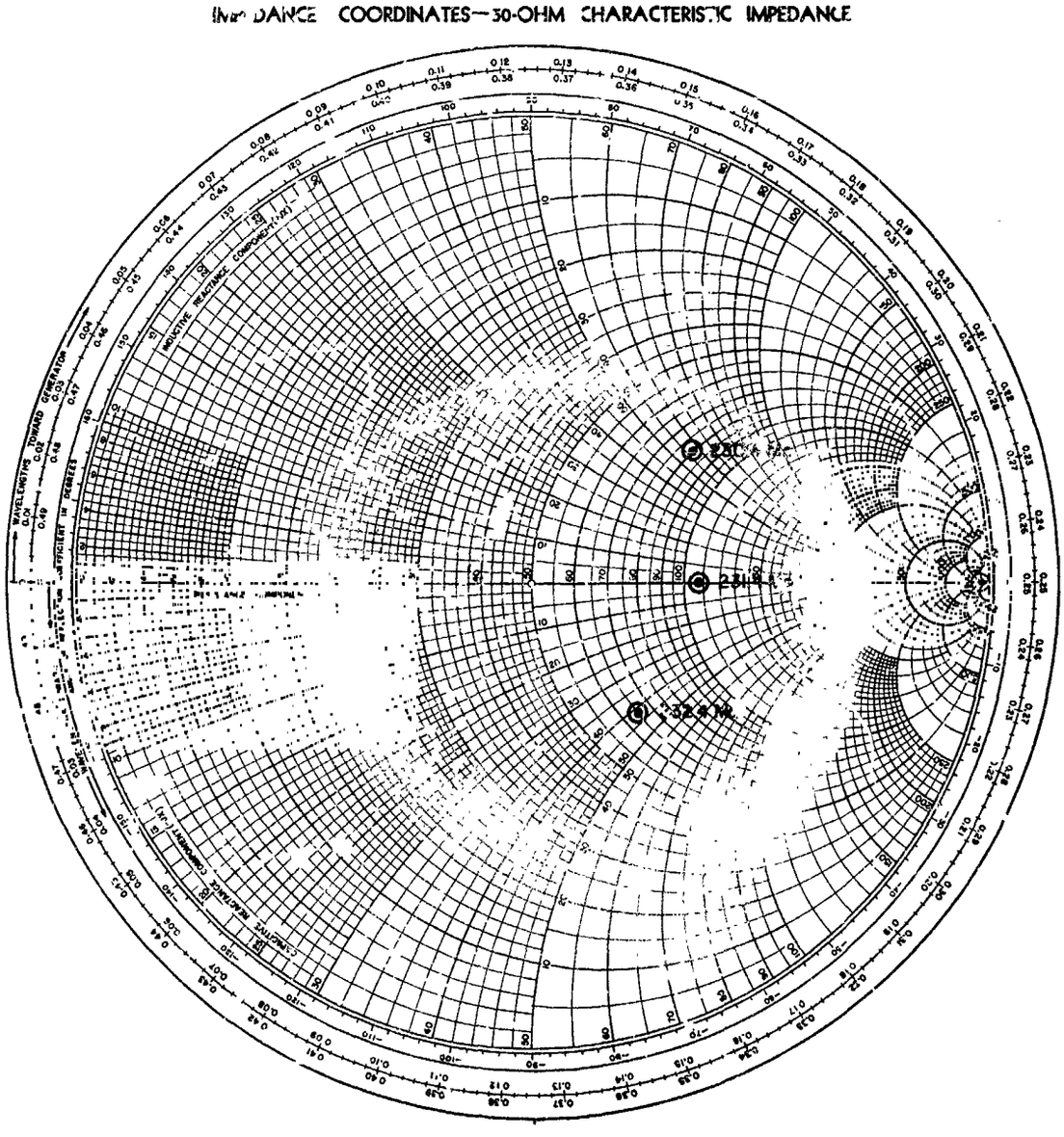


FIG. 2 - MODEL 2.041 IMPEDANCE AT 231.4 MC/SEC

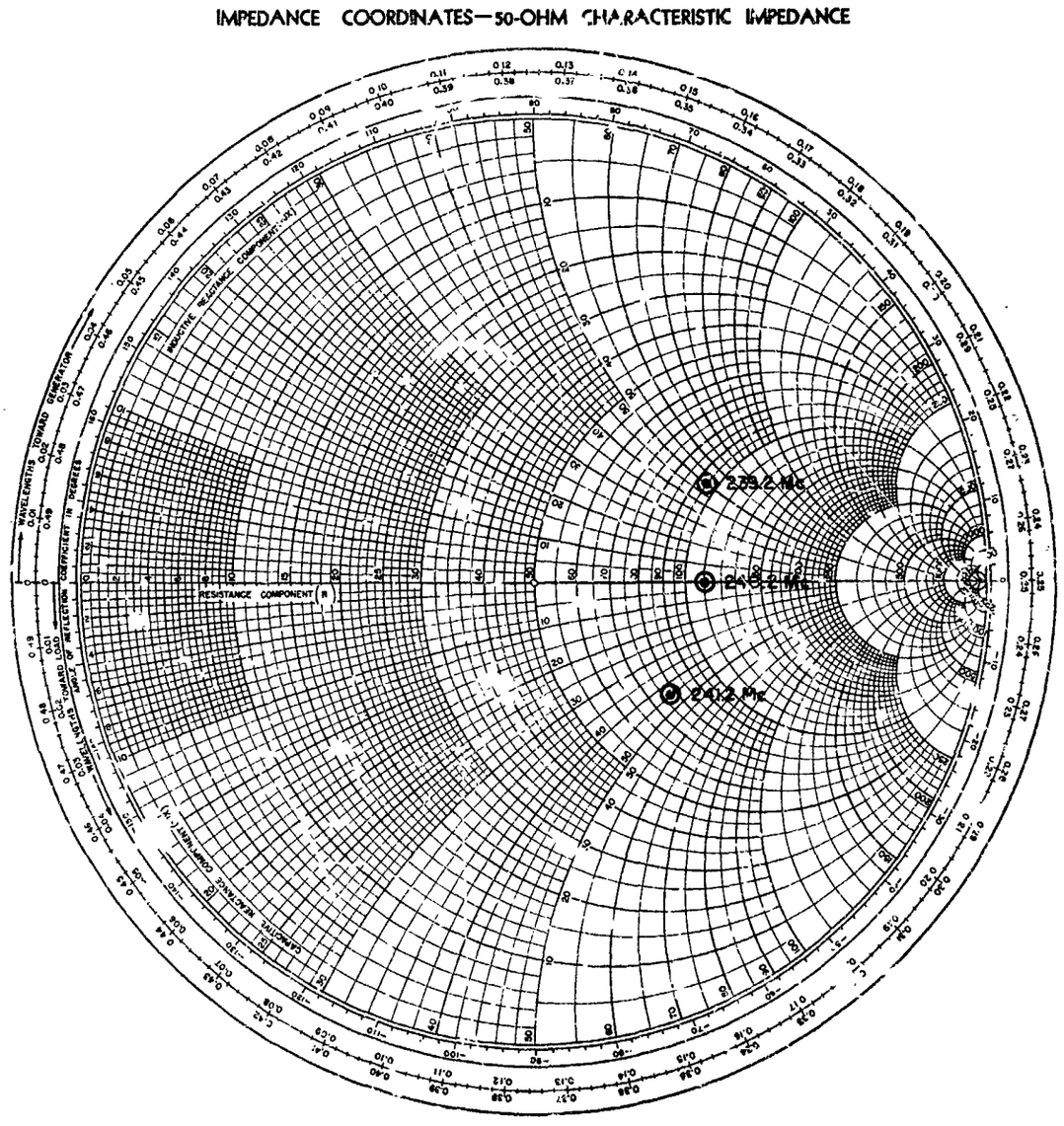


FIG. 3 - MODEL 2.041 IMPEDANCE AT 240.2 MC/SEC

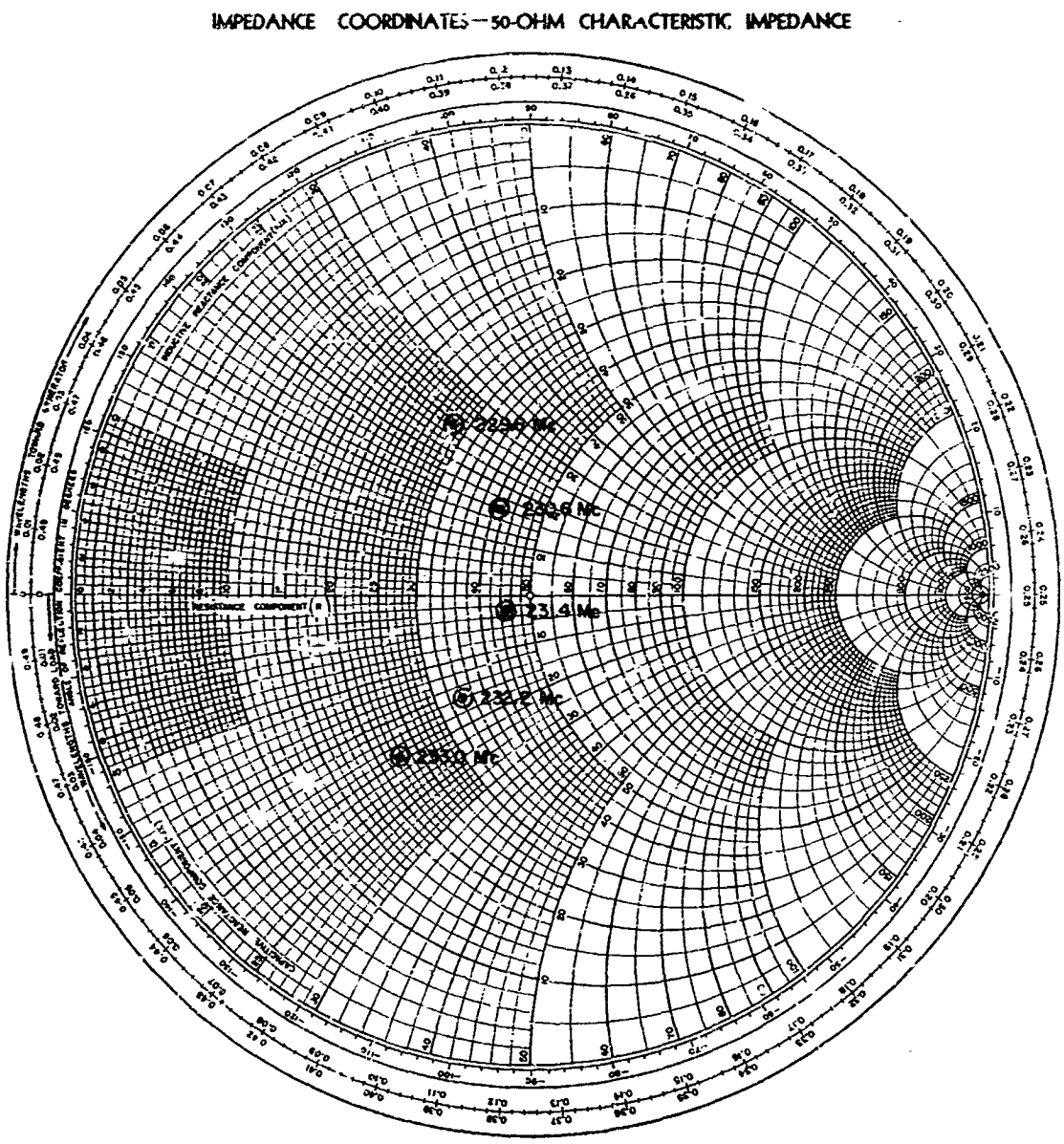


FIG. 4 - MODEL 2.041 IMPEDANCE ARRAY AT 231.4 MC/SEC

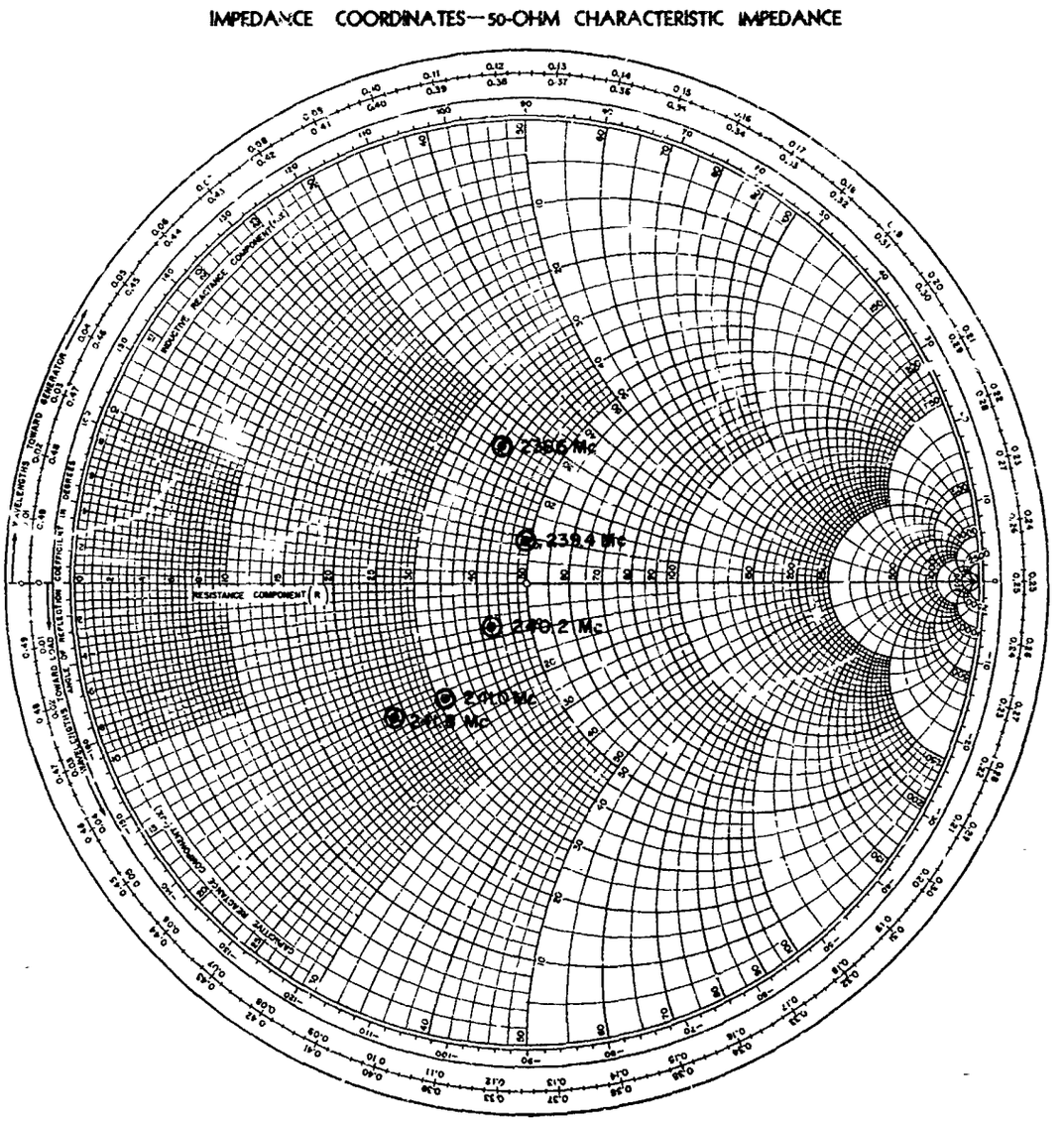


FIG. 5 - MODEL 2.041 IMPEDANCE ARRAY AT 240.2 MC/SEC

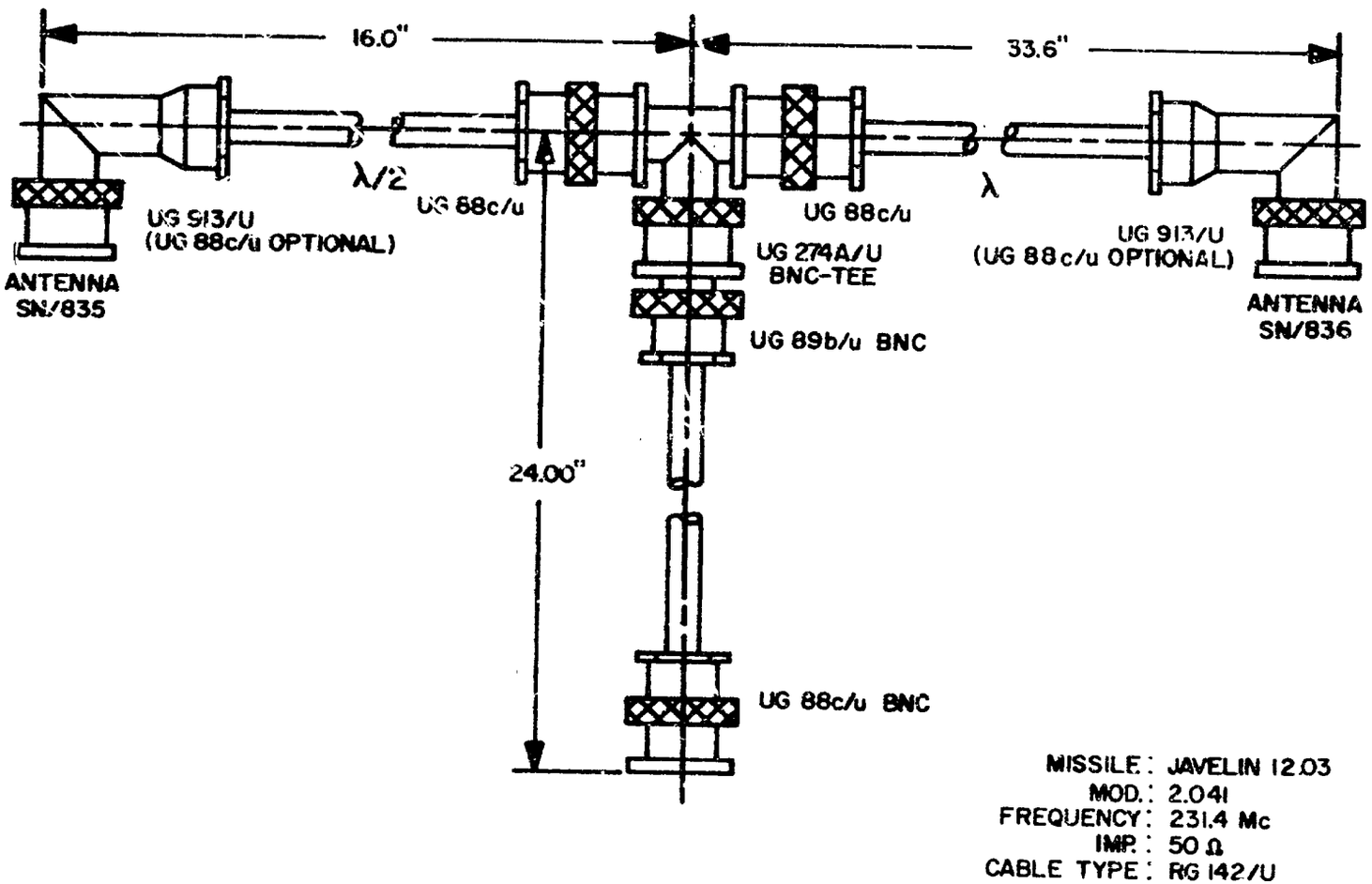


FIG. 6 - DRAWING OF ARRAY HARNESS FOR 231.4 MC/SEC

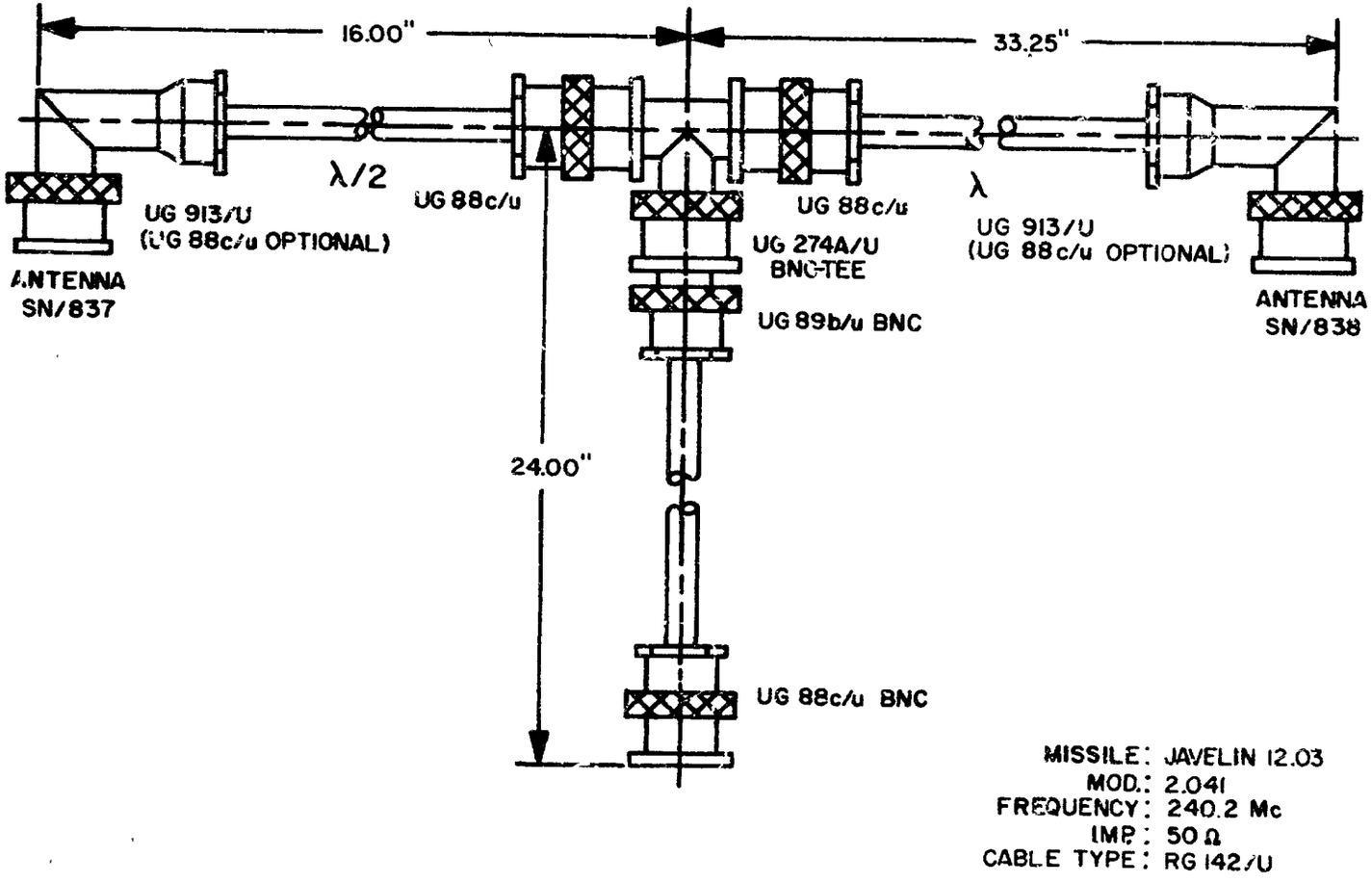


FIG. 7 - DRAWING OF ARRAY HARNESS FOR 240.2 MC/SEC

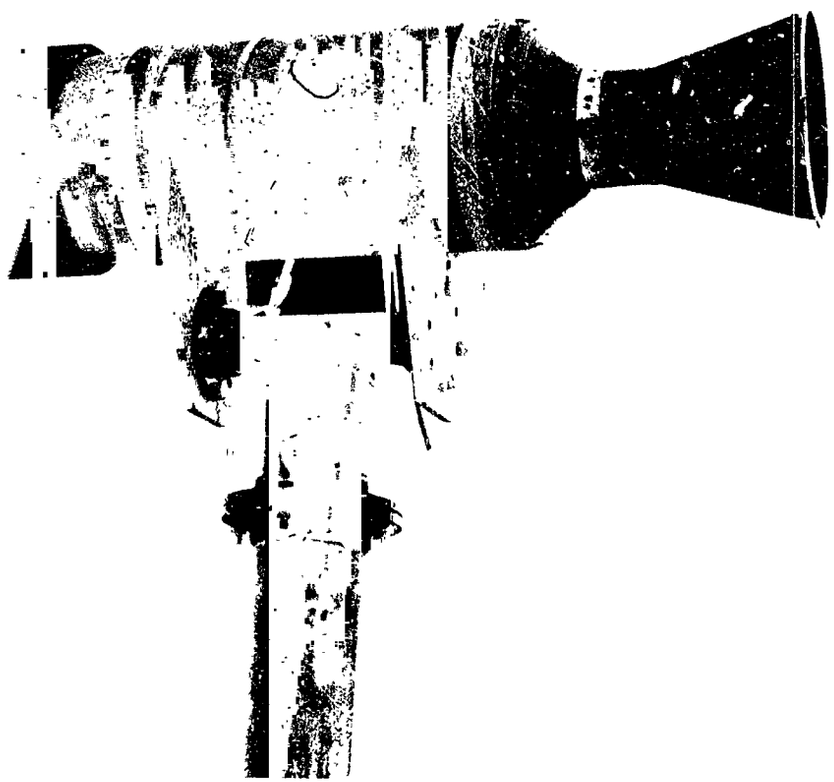
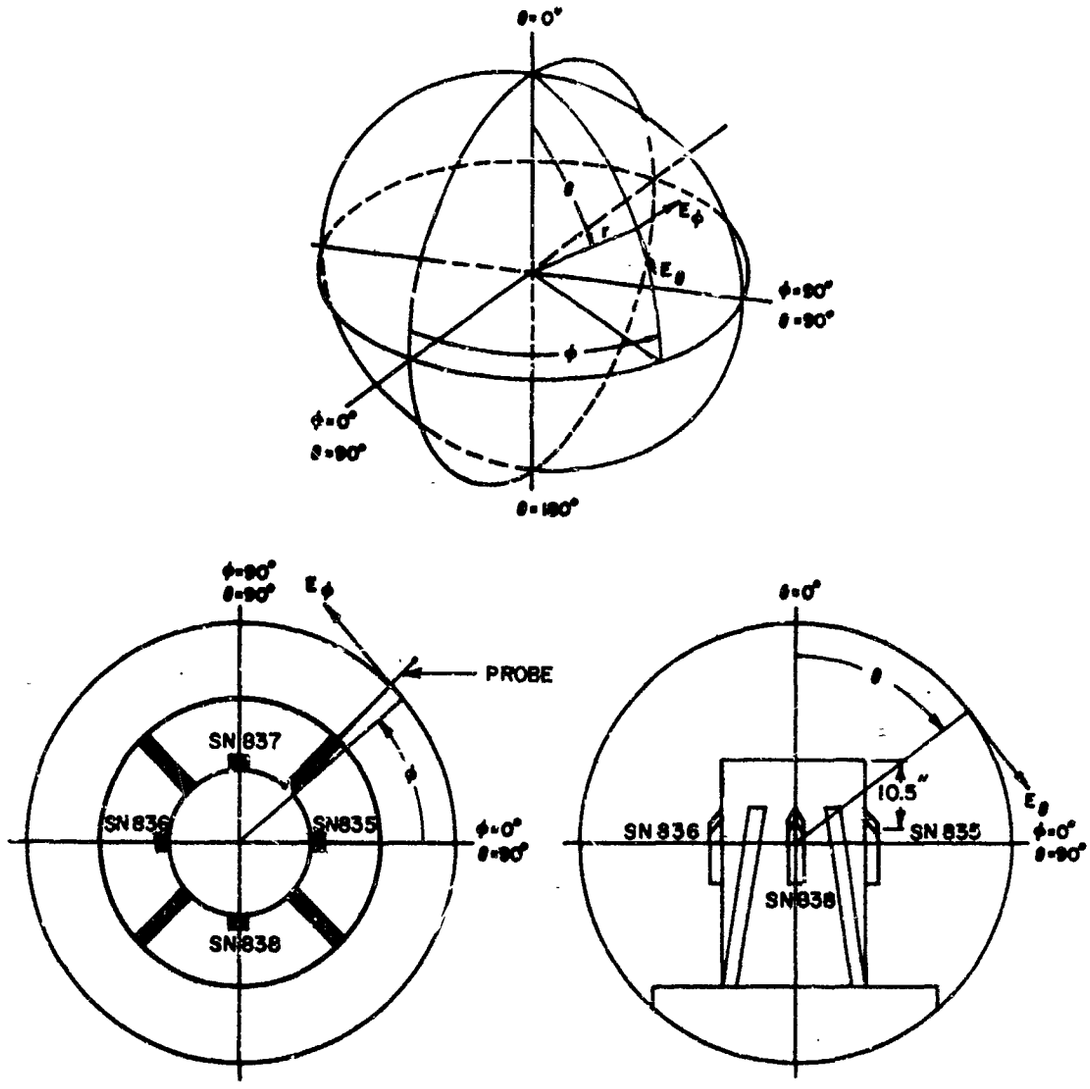


FIG. 8 - JAVELIN 12.03 ON ANTENNA RANGE FOR PATTERN MEASURING WITH NOSE CONE

FIG. 9 - JAVELIN 12.03 ON ANTENNA RANGE FOR PATTERN MEASURING WITHOUT NOSE CONE



Probe mounted six inches from the forward end. When the nose cone is in place, the probe lays against support arm.

FIG. 10 - COORDINATE SYSTEM FOR MODEL 2.041 QUADRALOOP ARRAY

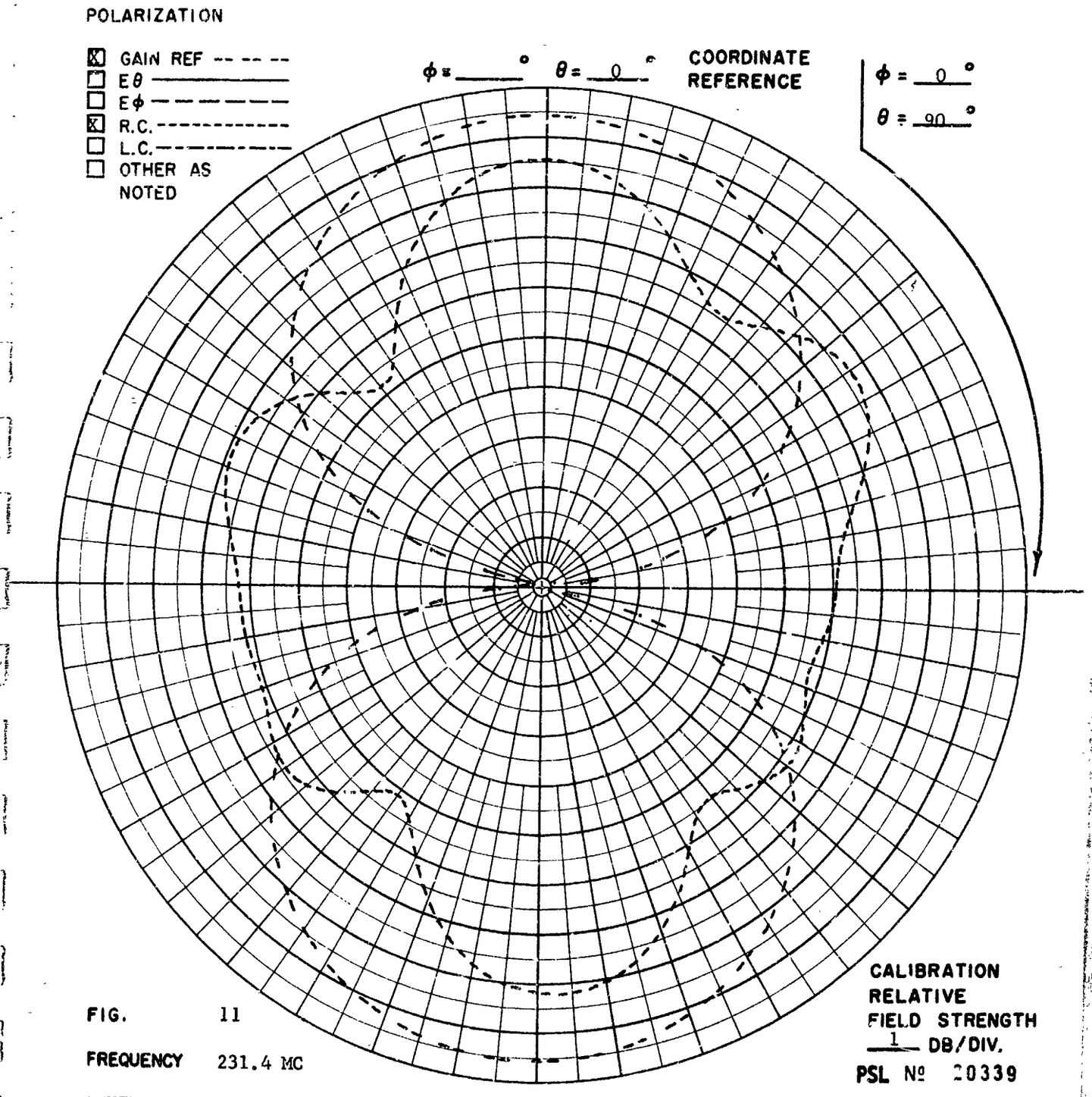


FIG. 11

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS THE GAIN AT $\theta = 180^\circ$, $\phi = 0^\circ$ IS -3 DB WITH RESPECT TO A STODDART HALF-WAVE DIPOLE.

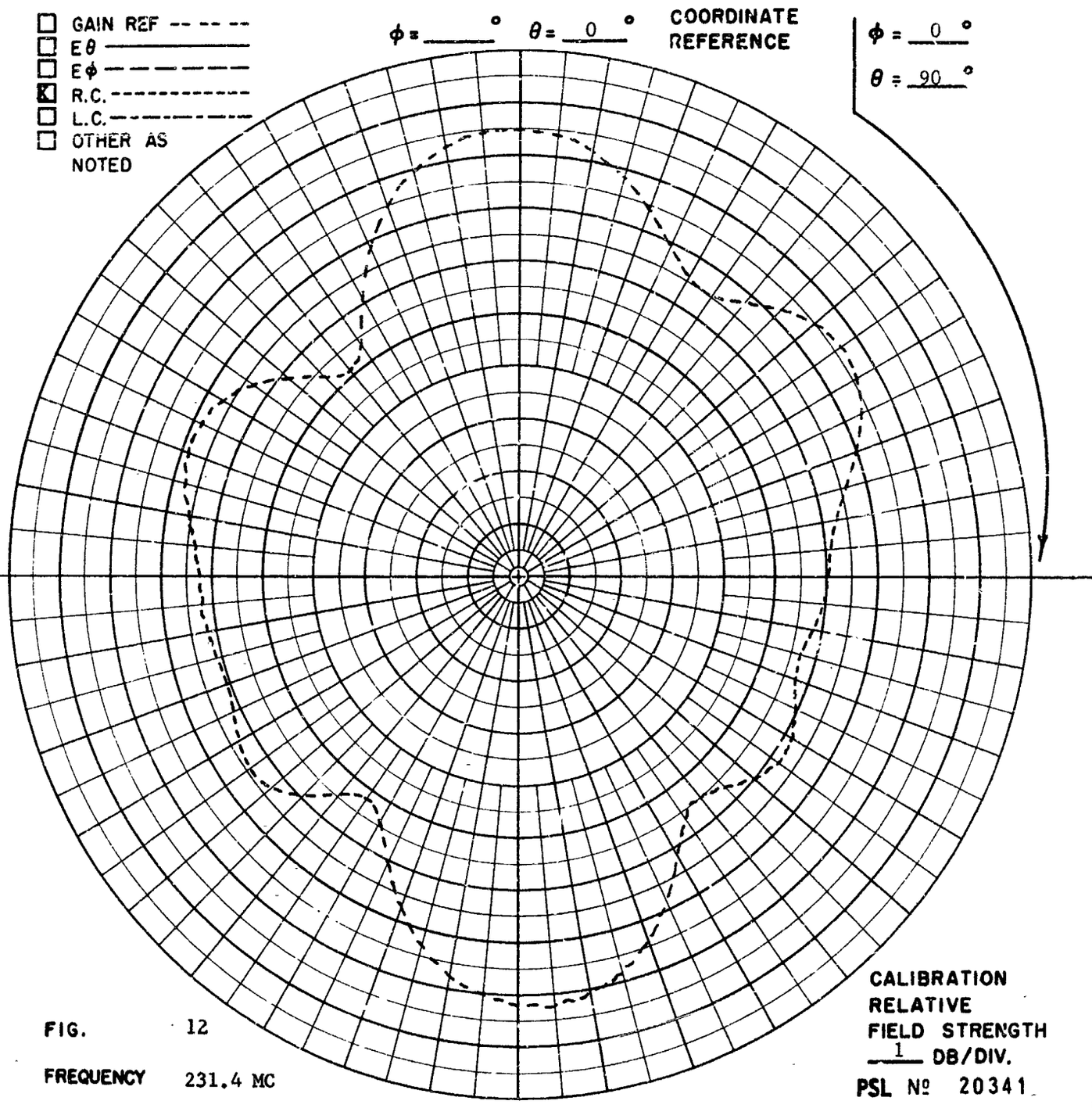


FIG. 12

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

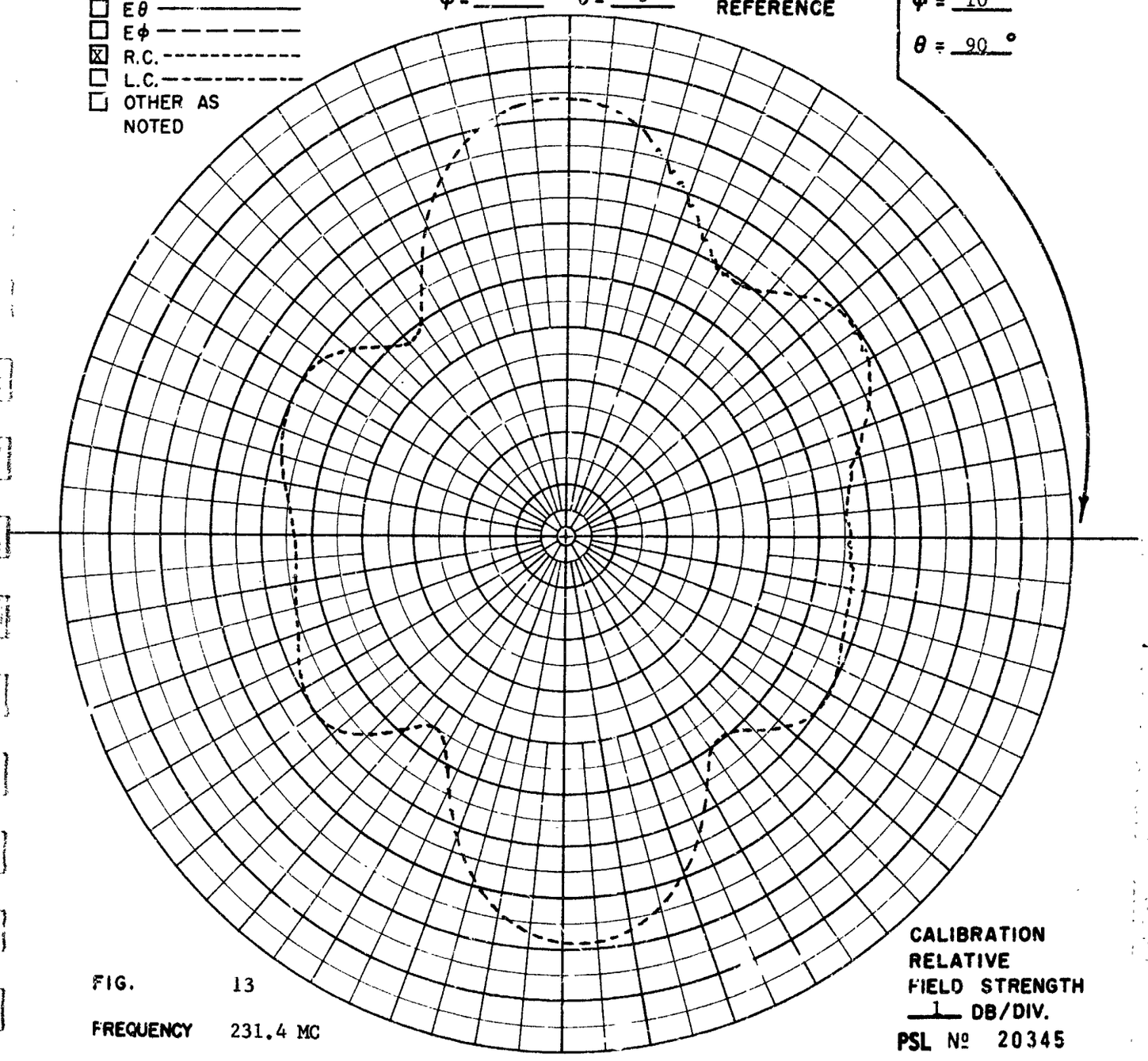
REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ————————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 10 °
θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20345

FIG. 13

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

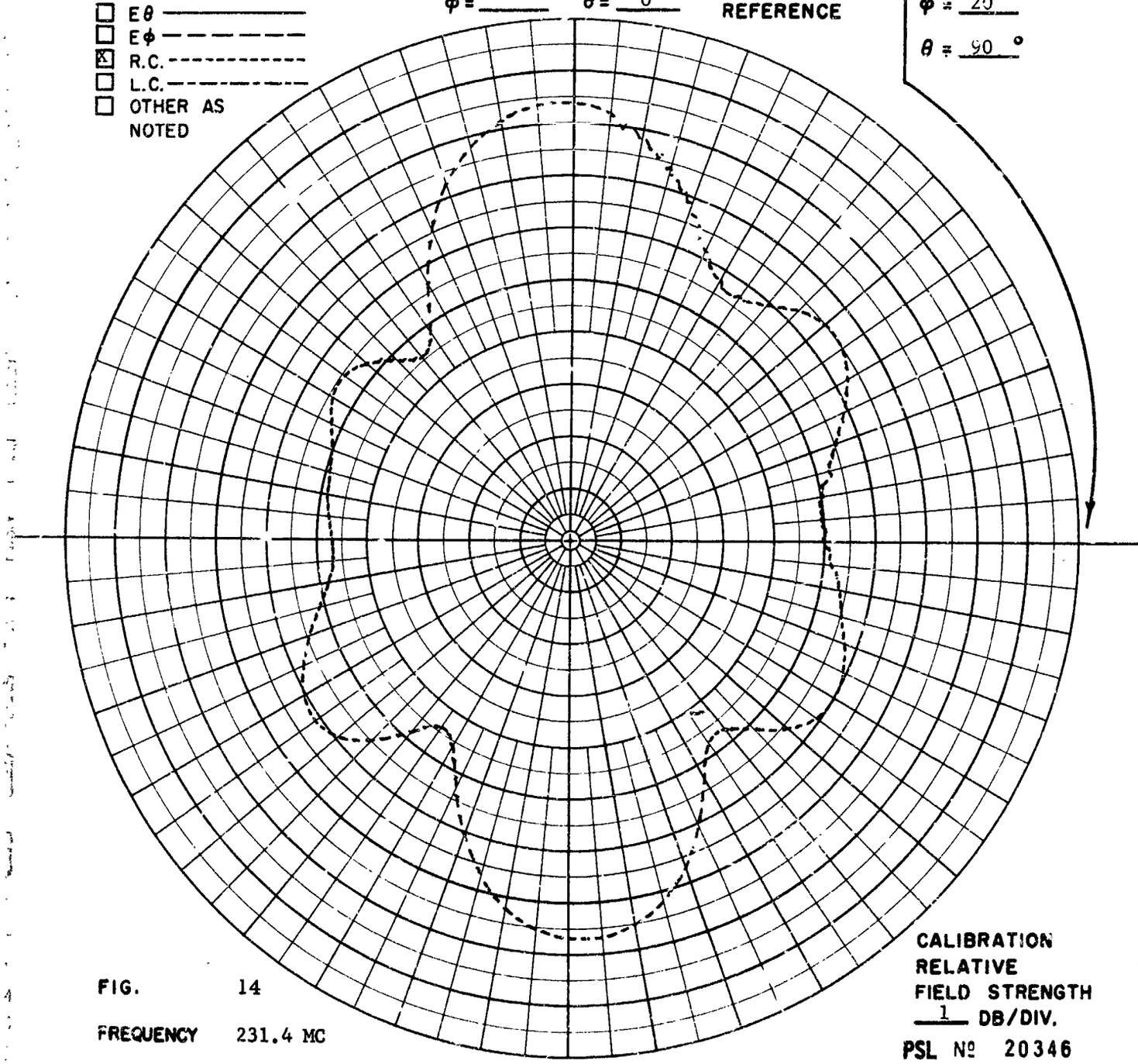
- ☐ GAIN REF -- -- --
- ☐ Eθ ——————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — · — · —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 20 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20346

FIG. 14

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

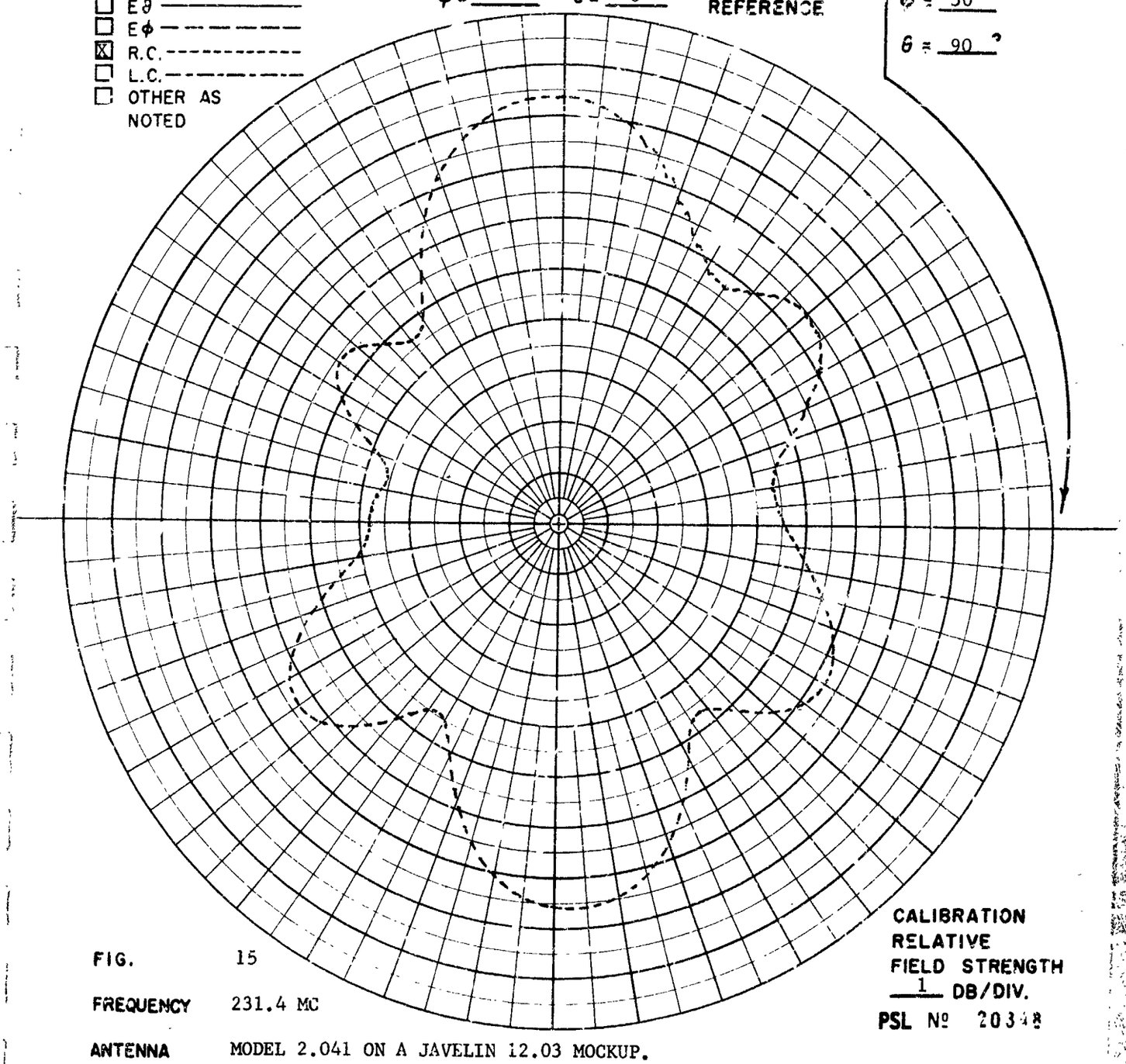
- ☐ GAIN REF -- -- --
- ☐ Eθ ————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — · — · —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 30 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20348

FIG. 15

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

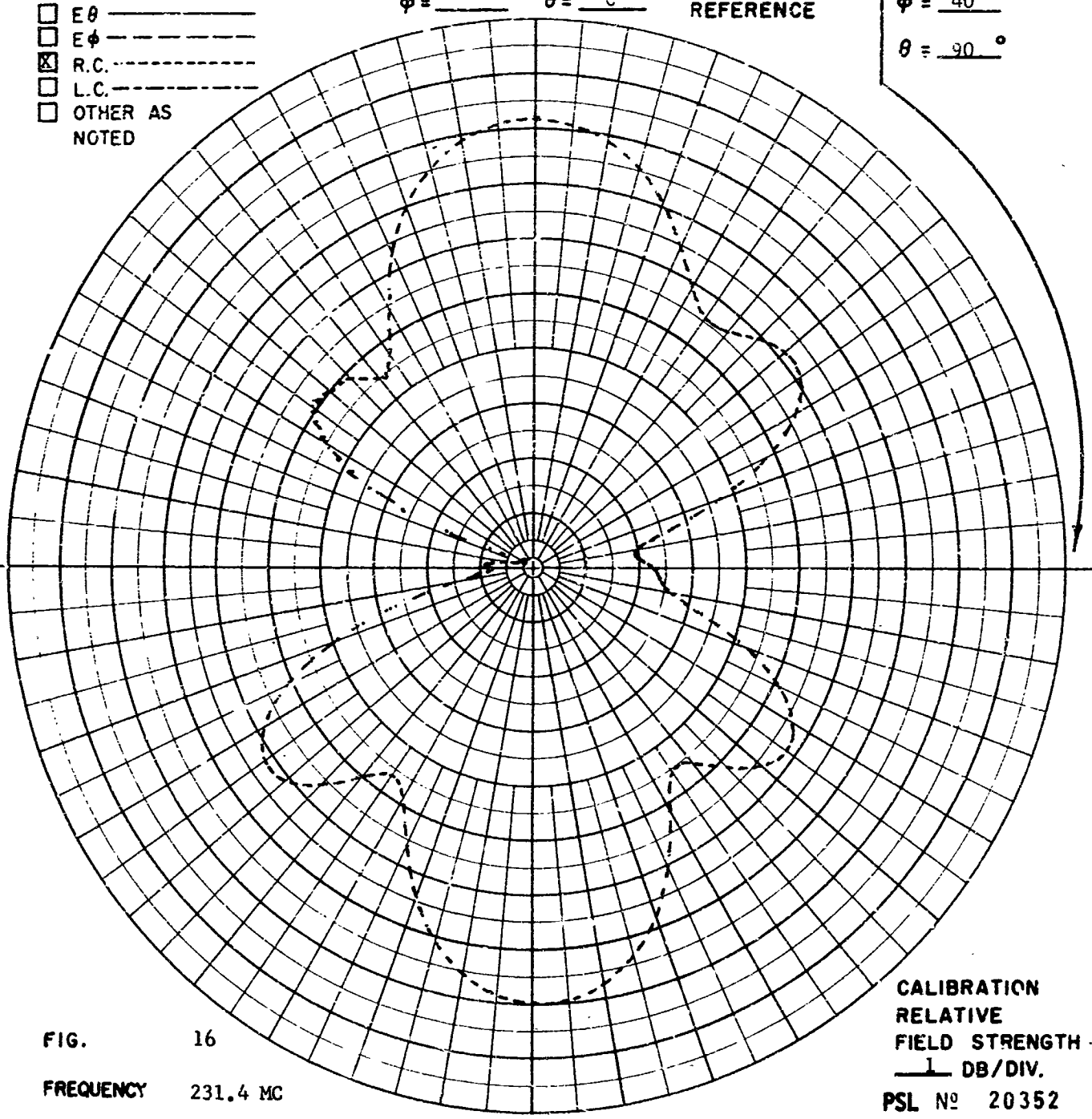
- ☐ GAIN REF -- -- --
- ☐ Eθ ————————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — · — · —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 40 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20352

FIG. 16

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

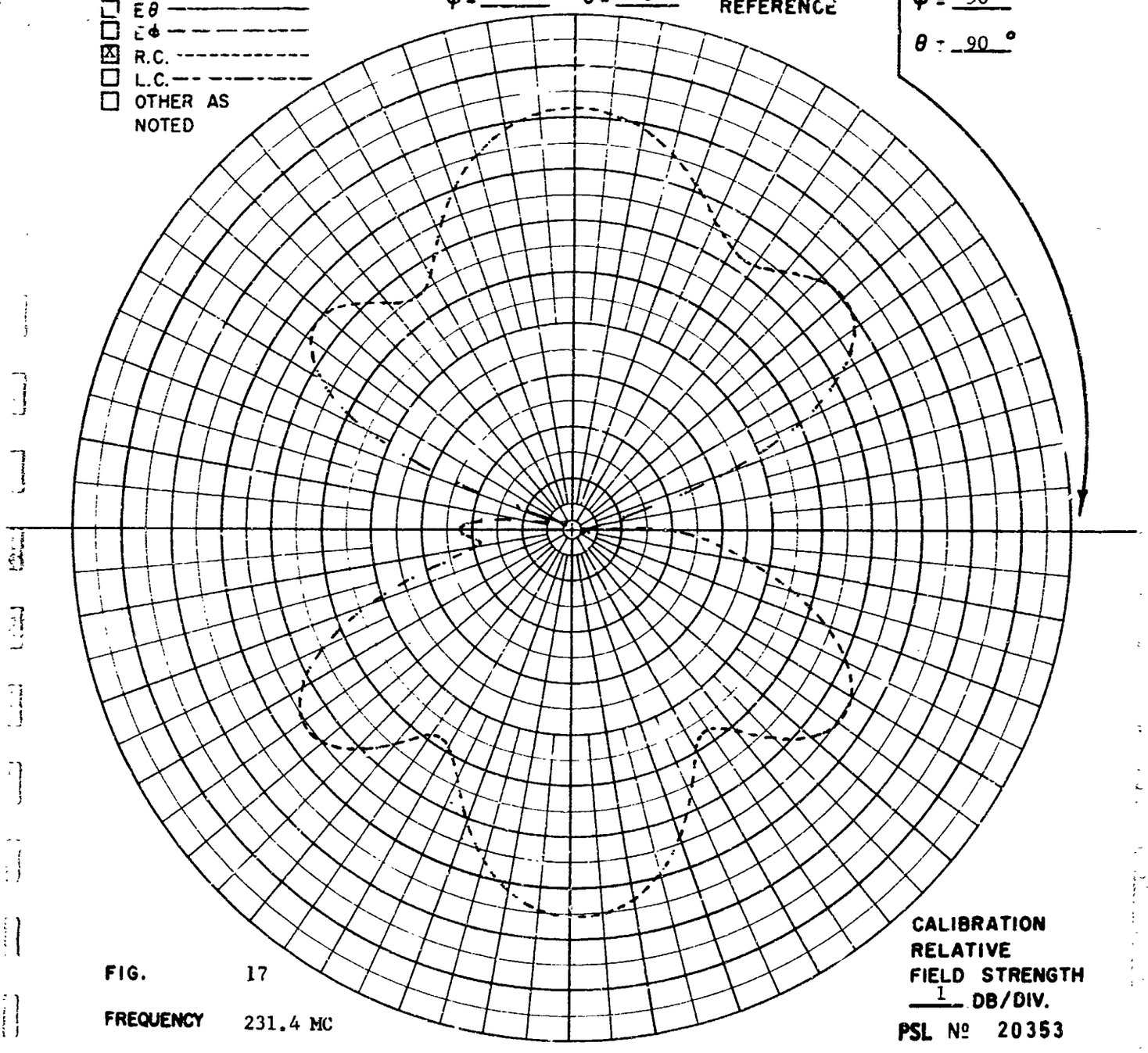
- ☐ GAIN REF -- -- --
- ☐ Eθ ———
- ☐ Eφ — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — —
- ☐ OTHER AS NOTED

φ = ____ θ = 0 °

COORDINATE REFERENCE

φ = 50 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20353

FIG. 17

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

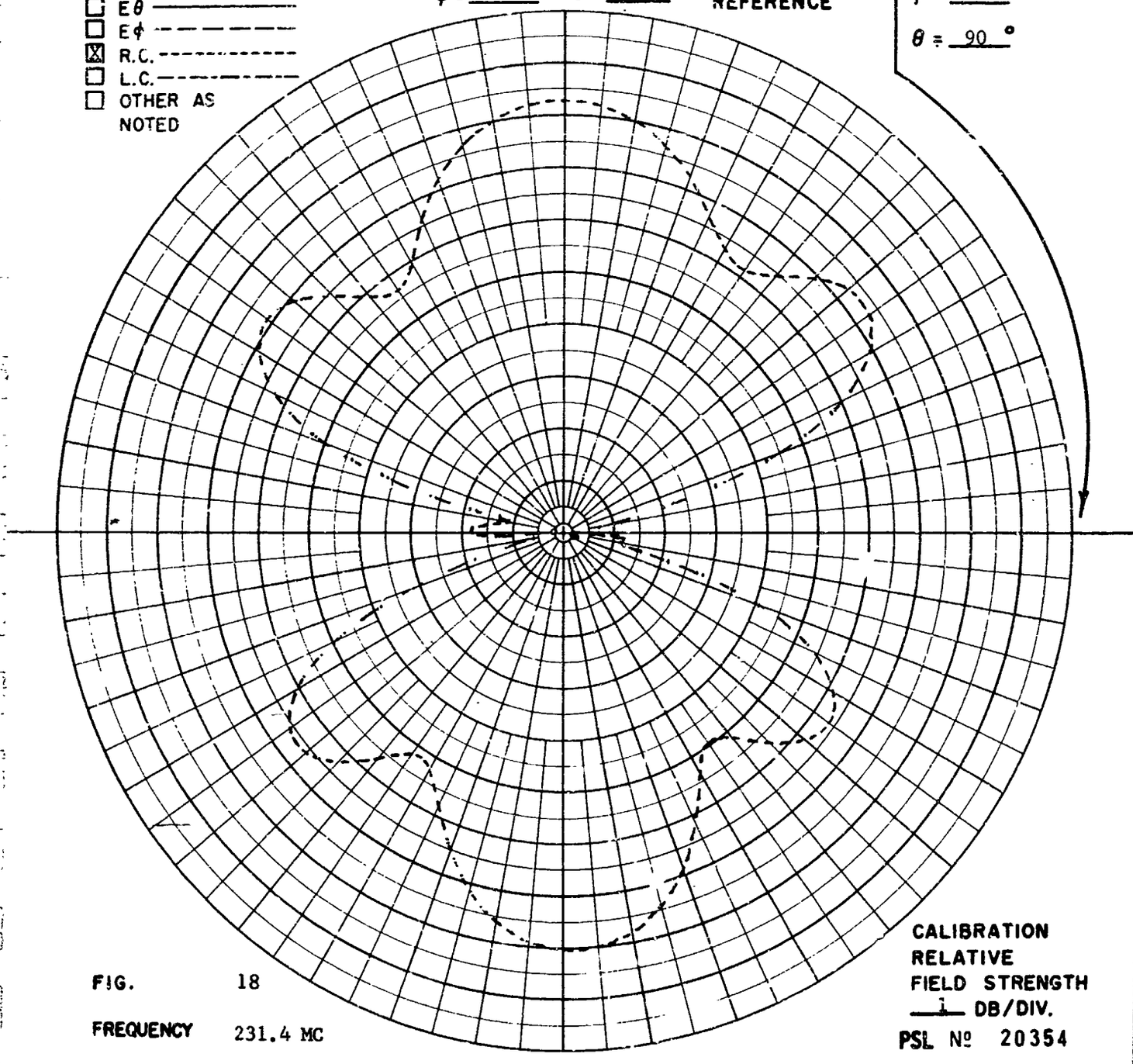
- ☐ GAIN REF -- -- --
- ☐ Eθ ————
- ☐ Eϕ — — — —
- ☒ R.C. ----------
- ☐ L.C. — · — · —
- ☐ OTHER AS NOTED

ϕ = ____ ° θ = 0 °

COORDINATE REFERENCE

ϕ = 60 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20354

FIG. 18

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

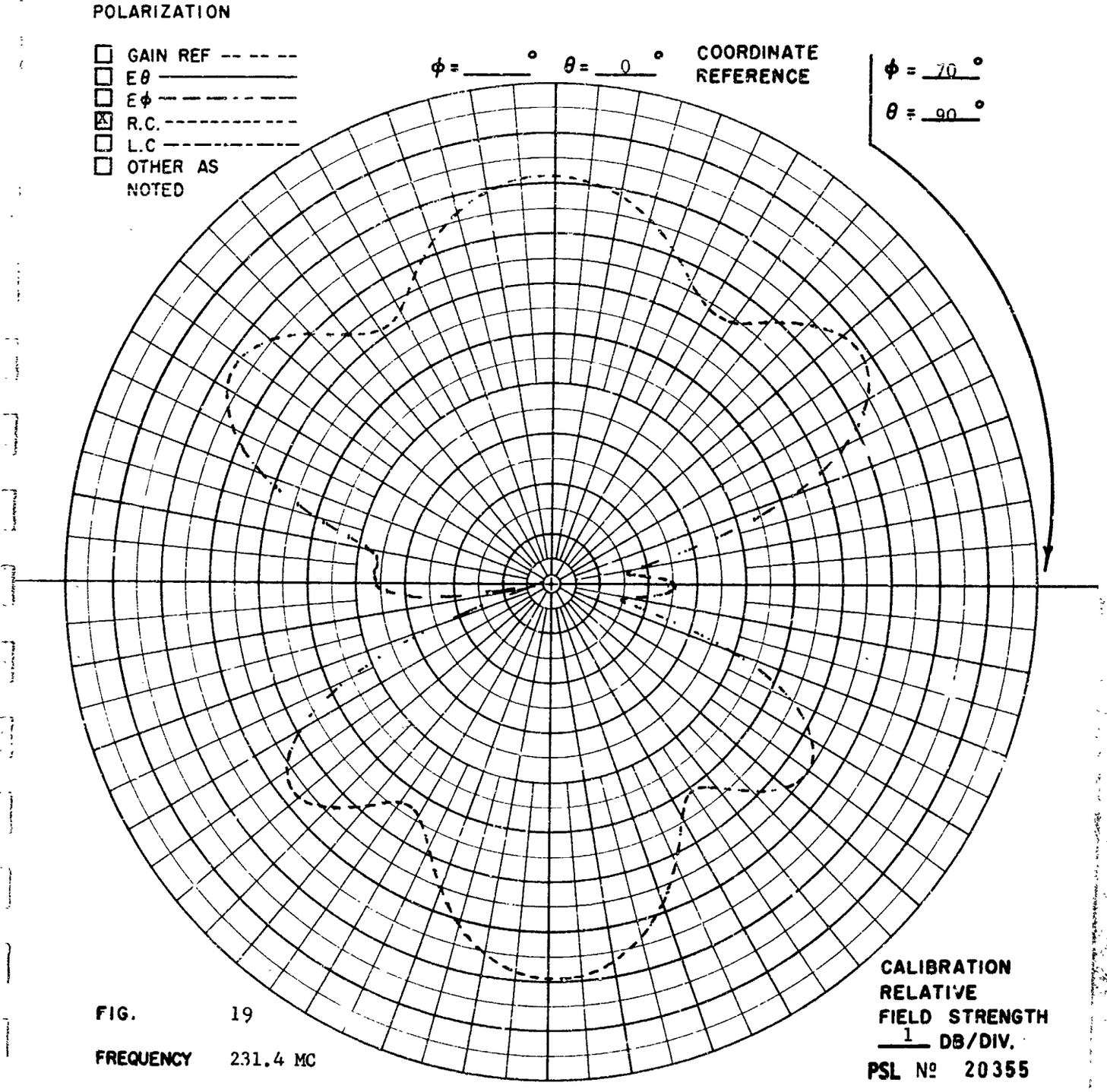


FIG. 19

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

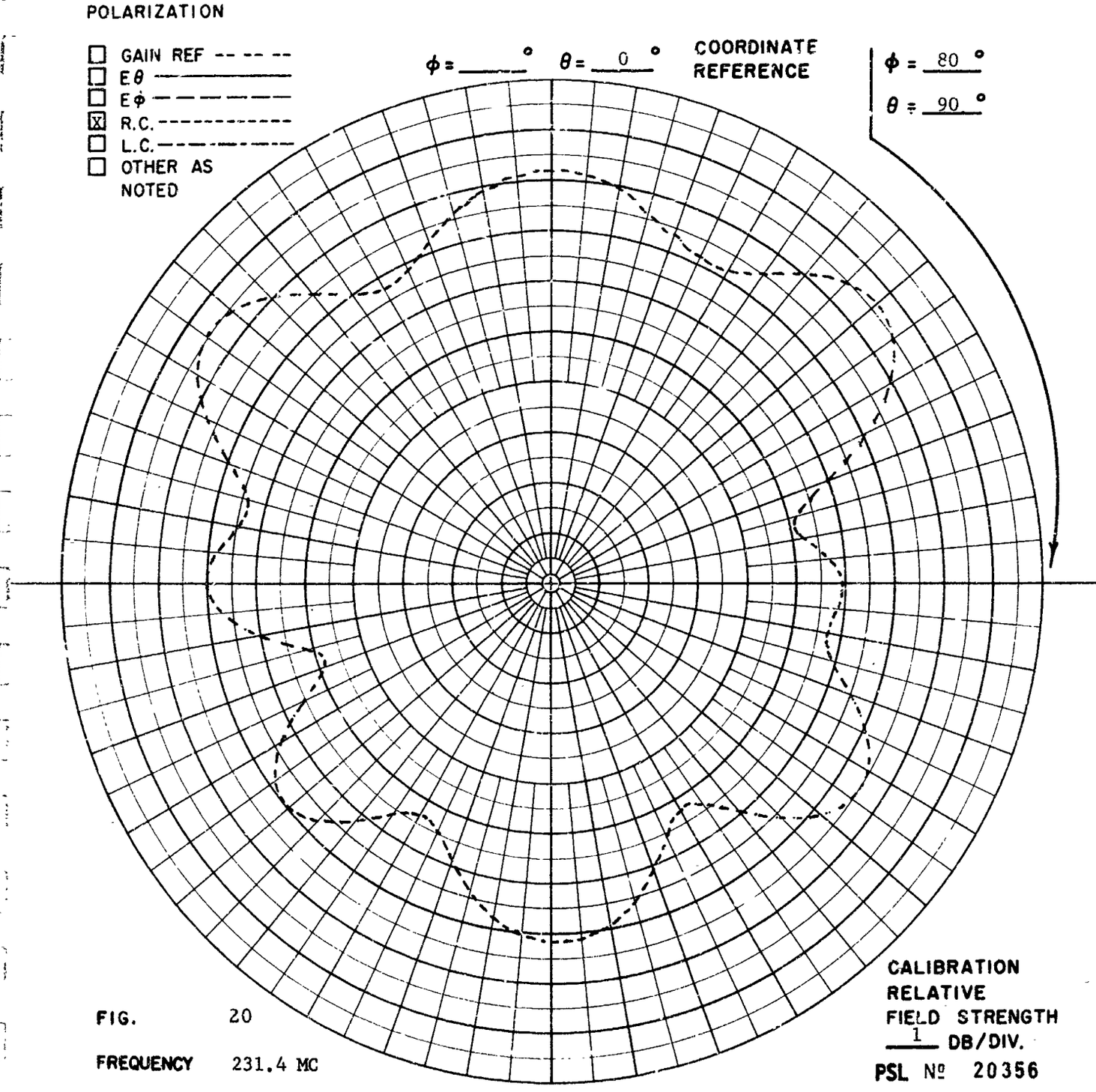


FIG. 20

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

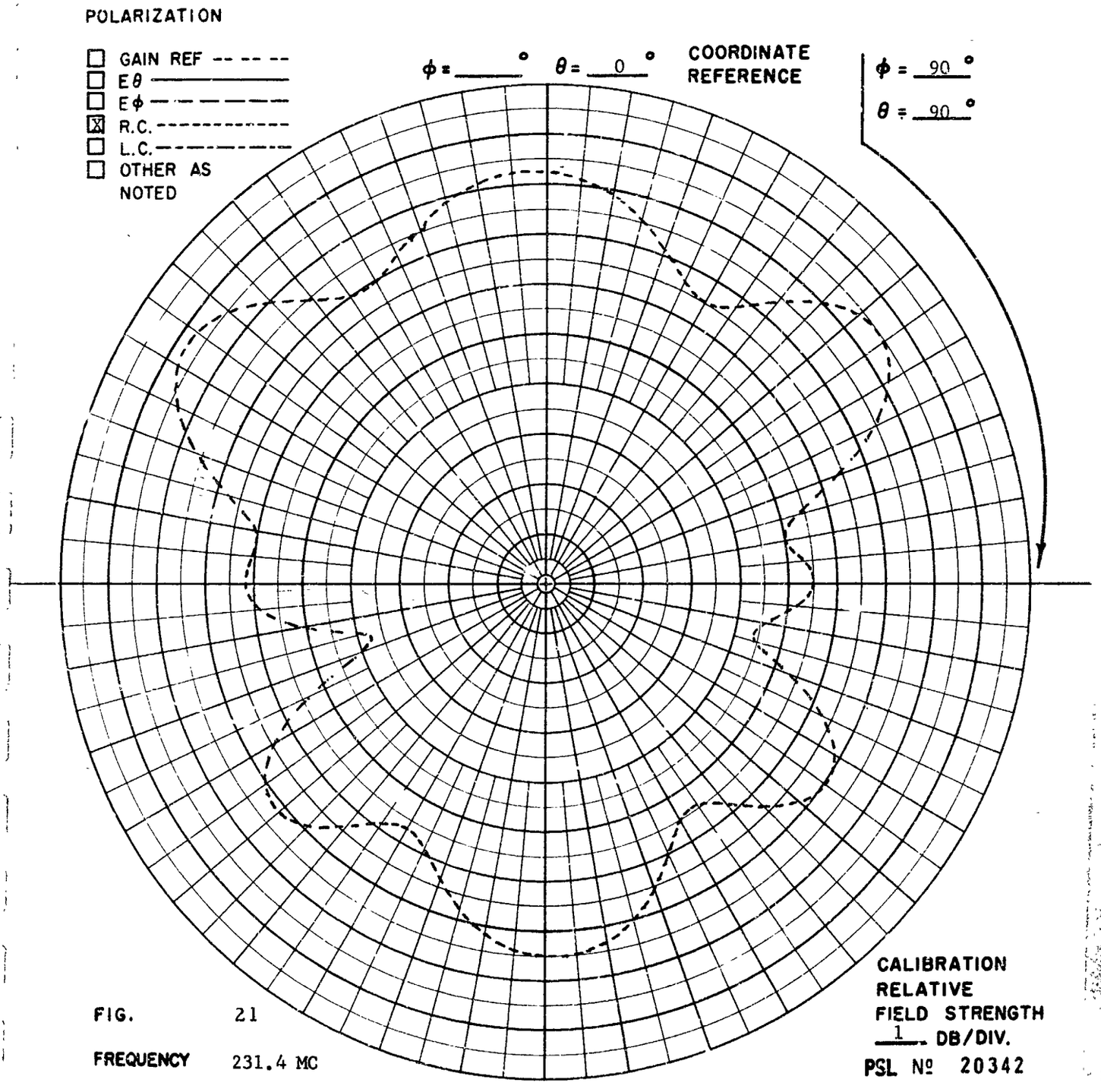


FIG. 21

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

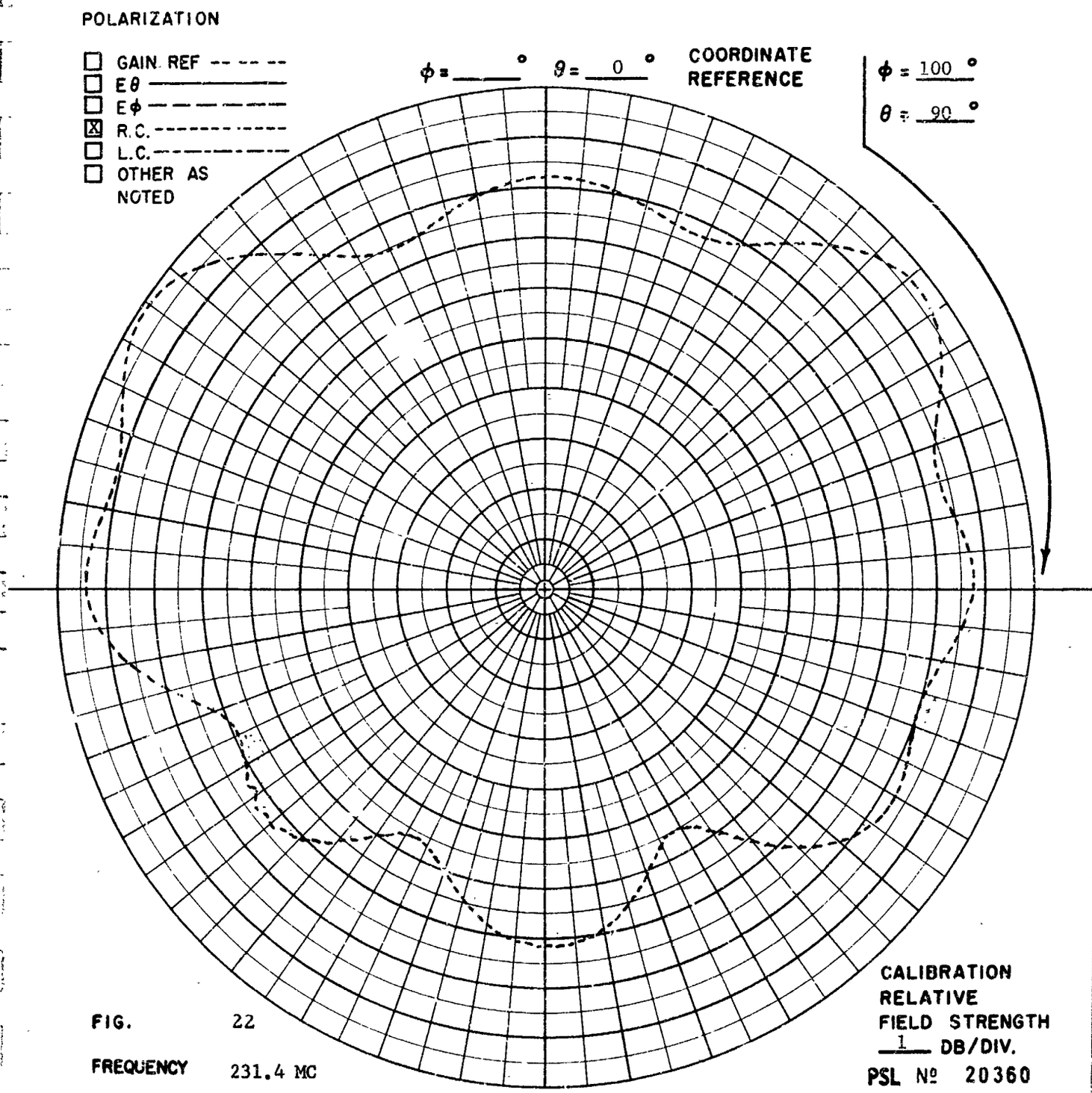


FIG. 22

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

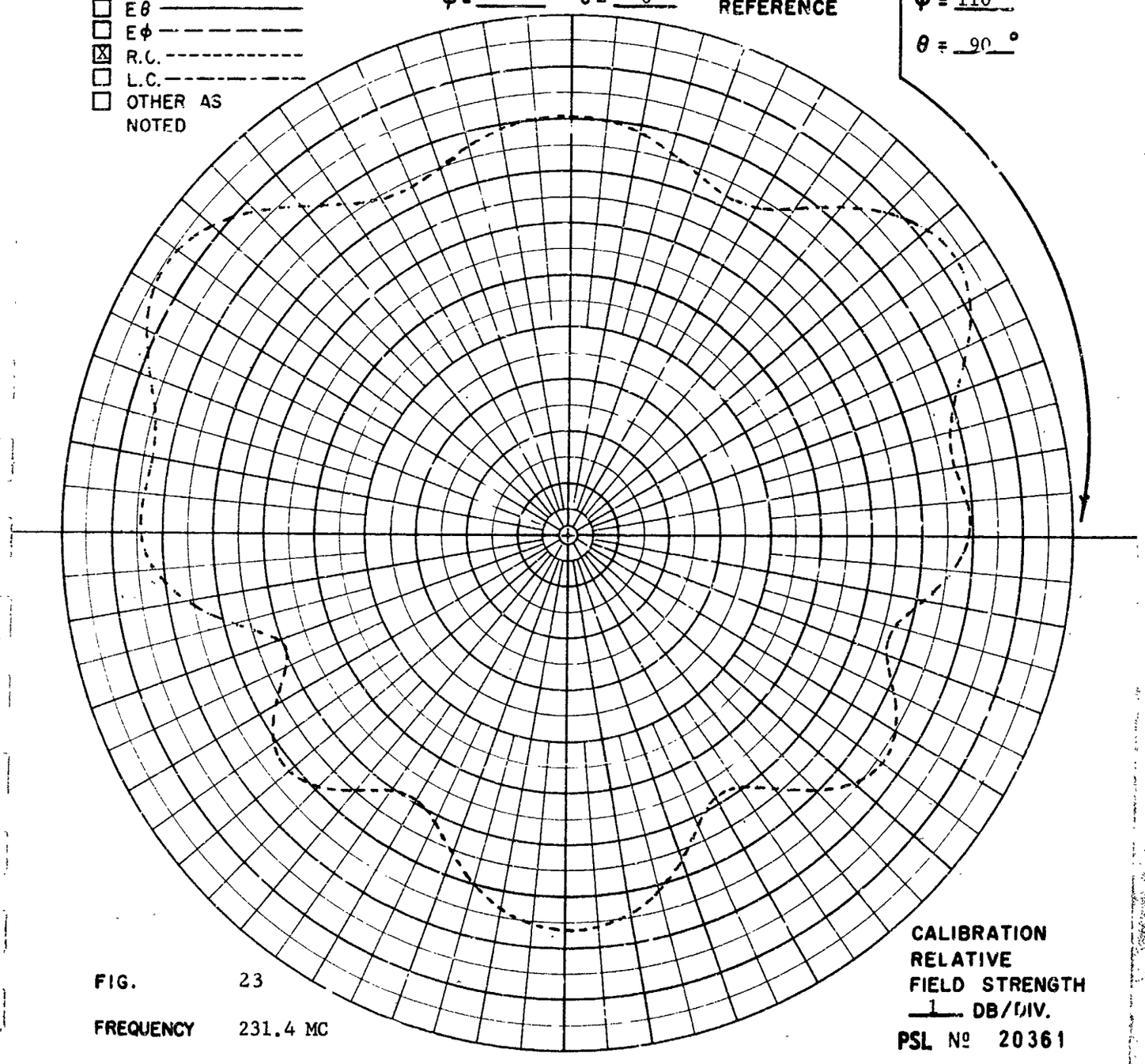
POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ————
- ☐ Eφ — — — —
- ☒ R.C. ----------
- ☐ L.C. —·—·—·—
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 110 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20361

FIG. 23

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

POLARIZATION

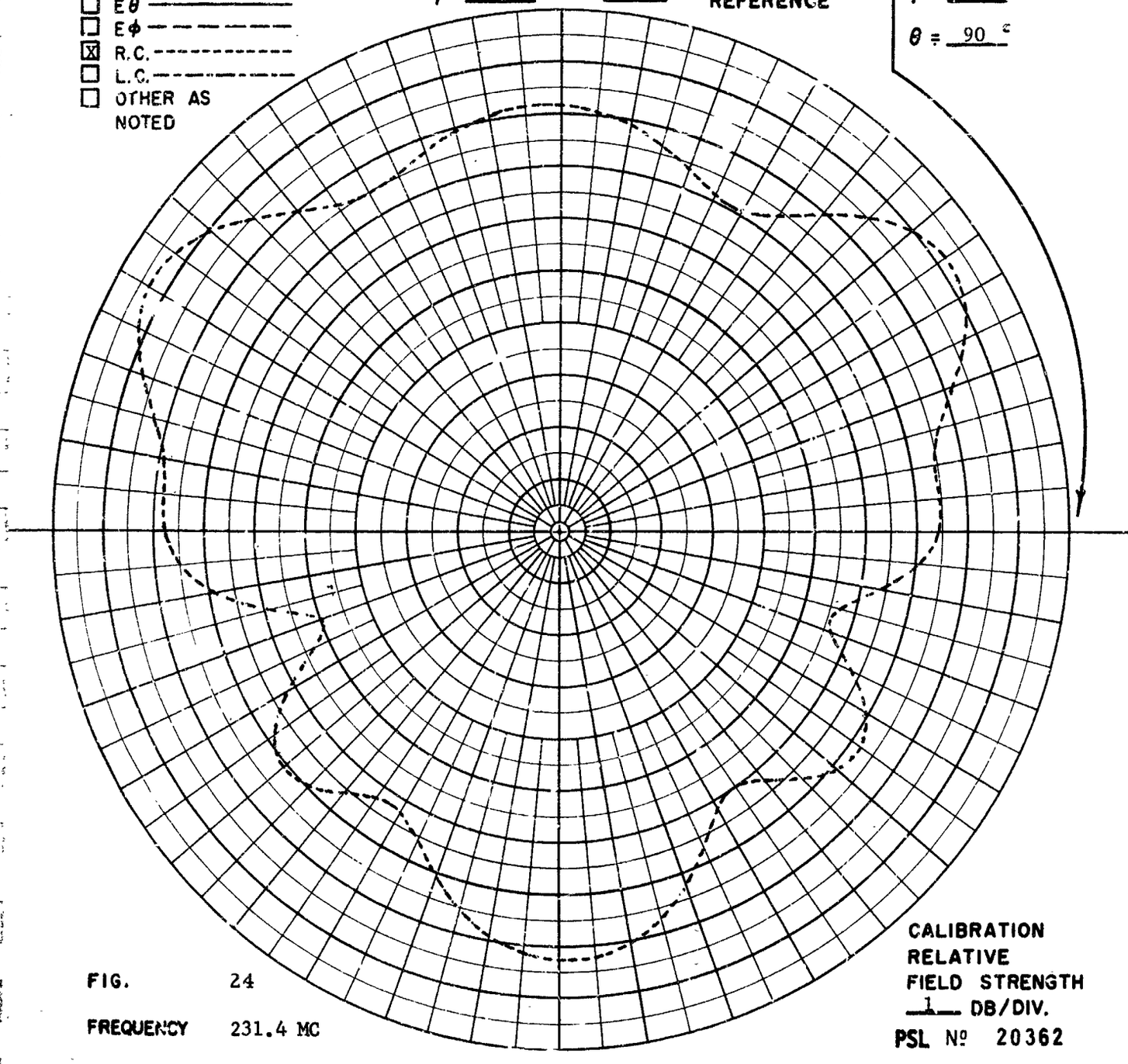
- ☐ GAIN REF -- -- --
- ☐ Eθ ——————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 120 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20362

FIG. 24

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

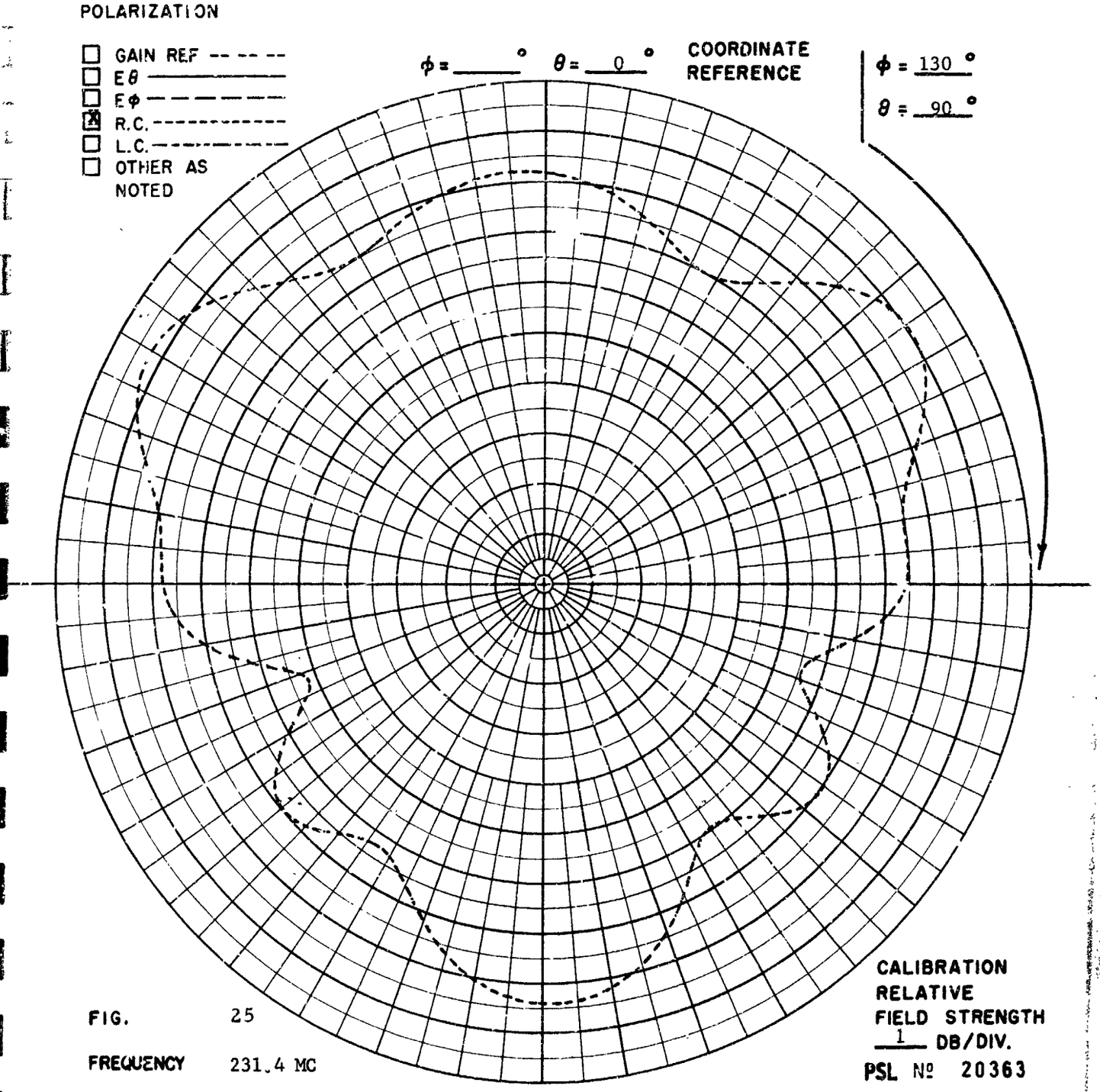


FIG. 25

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

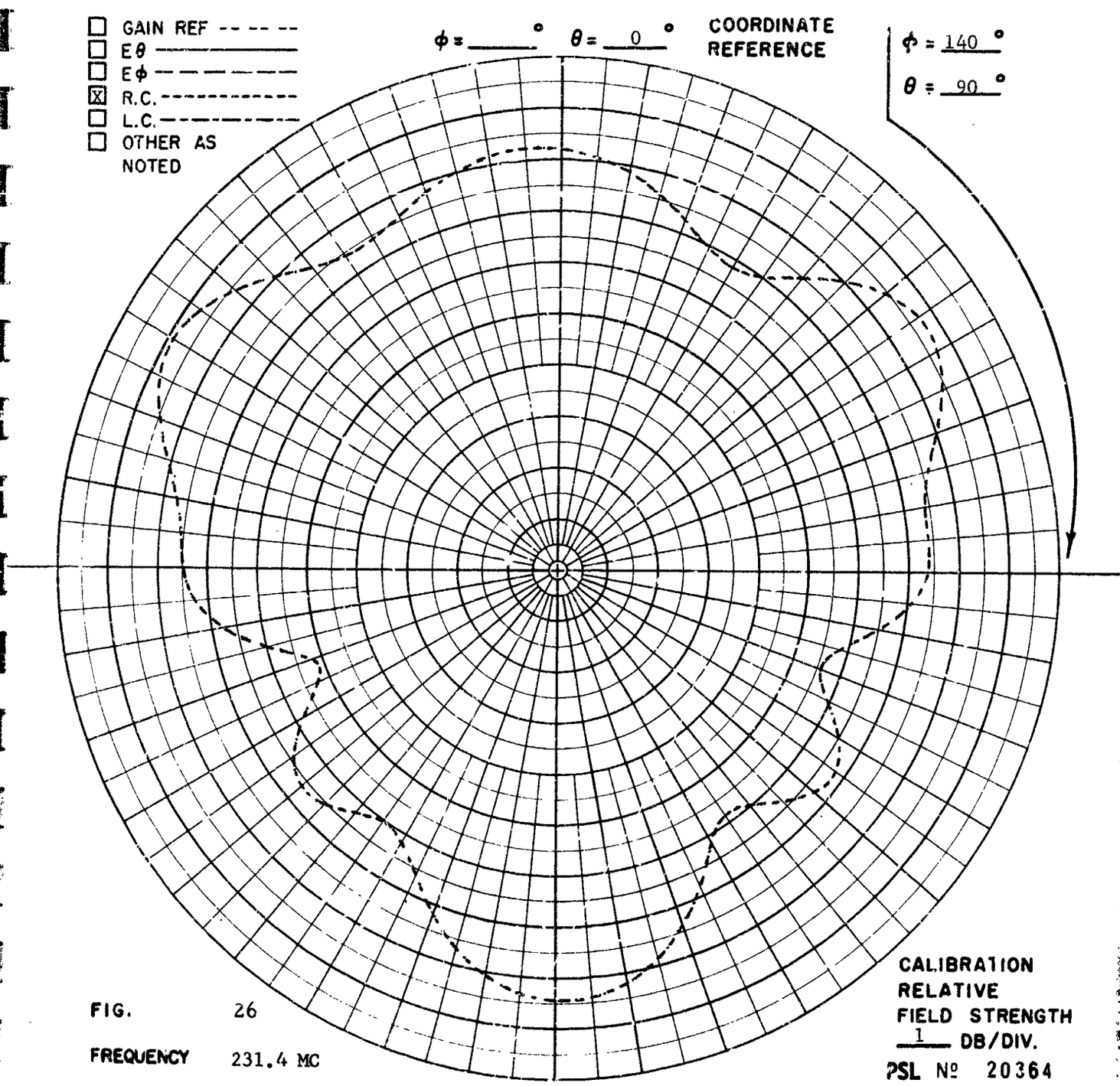


FIG. 26

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

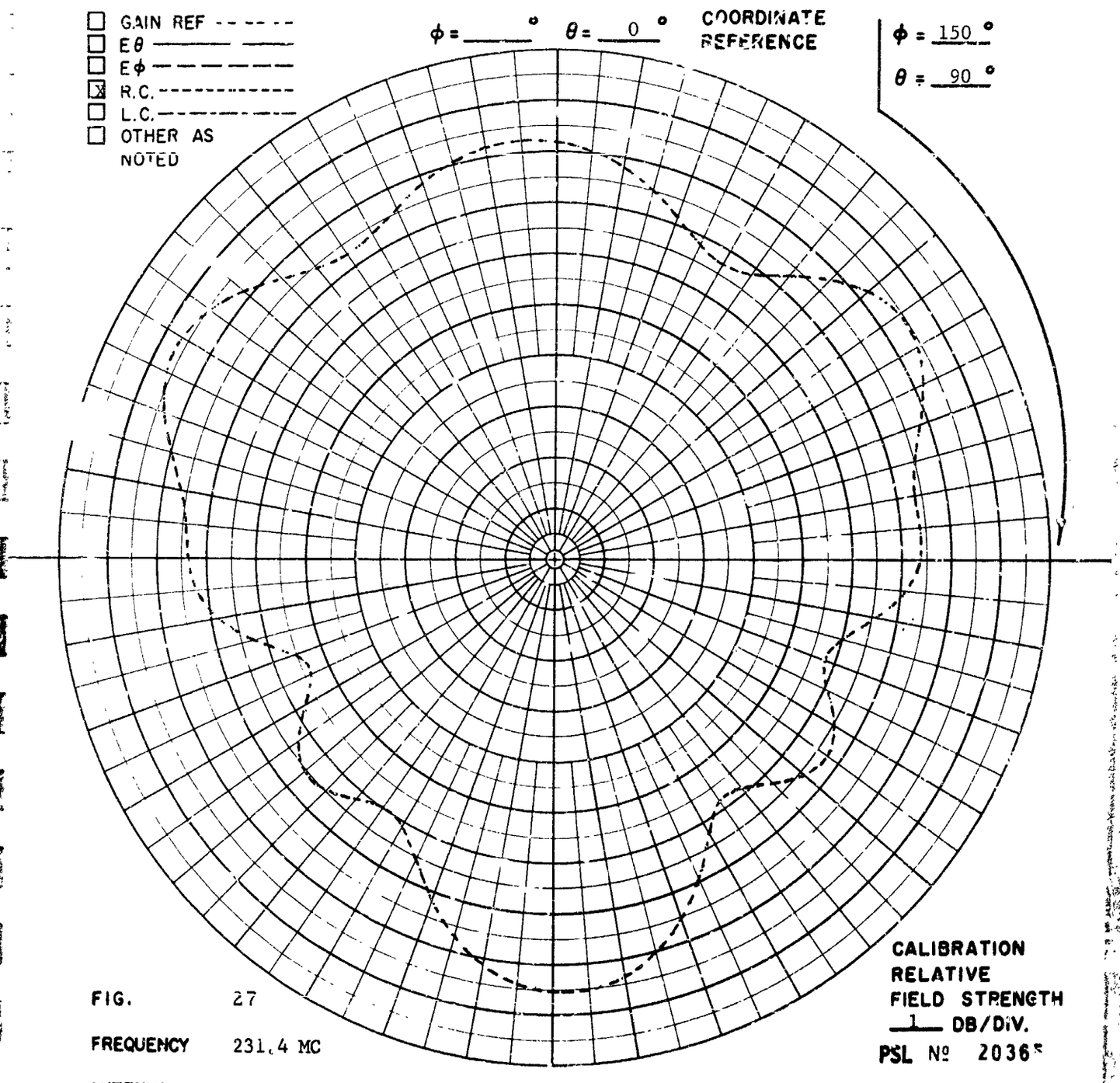


FIG. 27

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

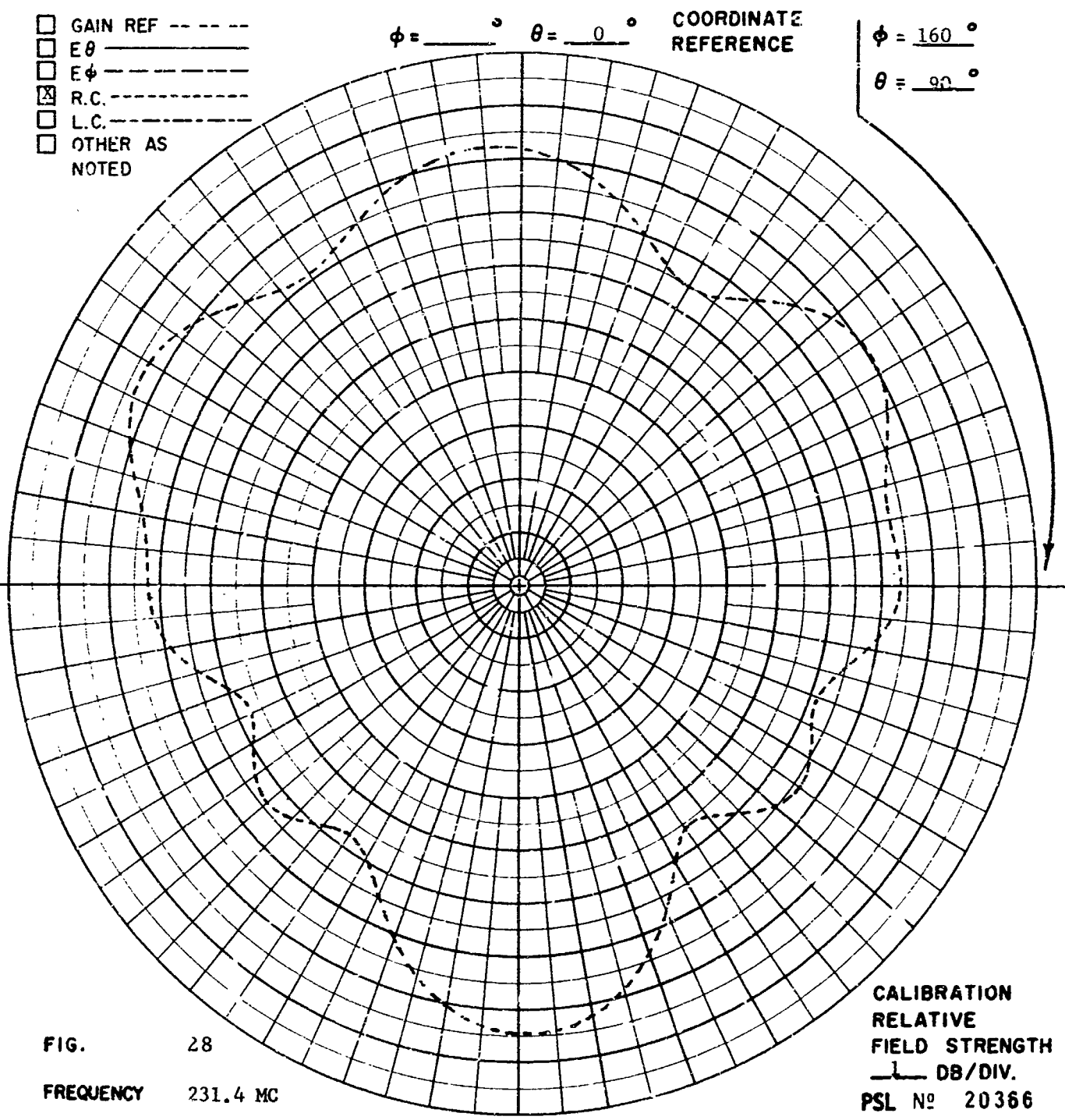


FIG. 28

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

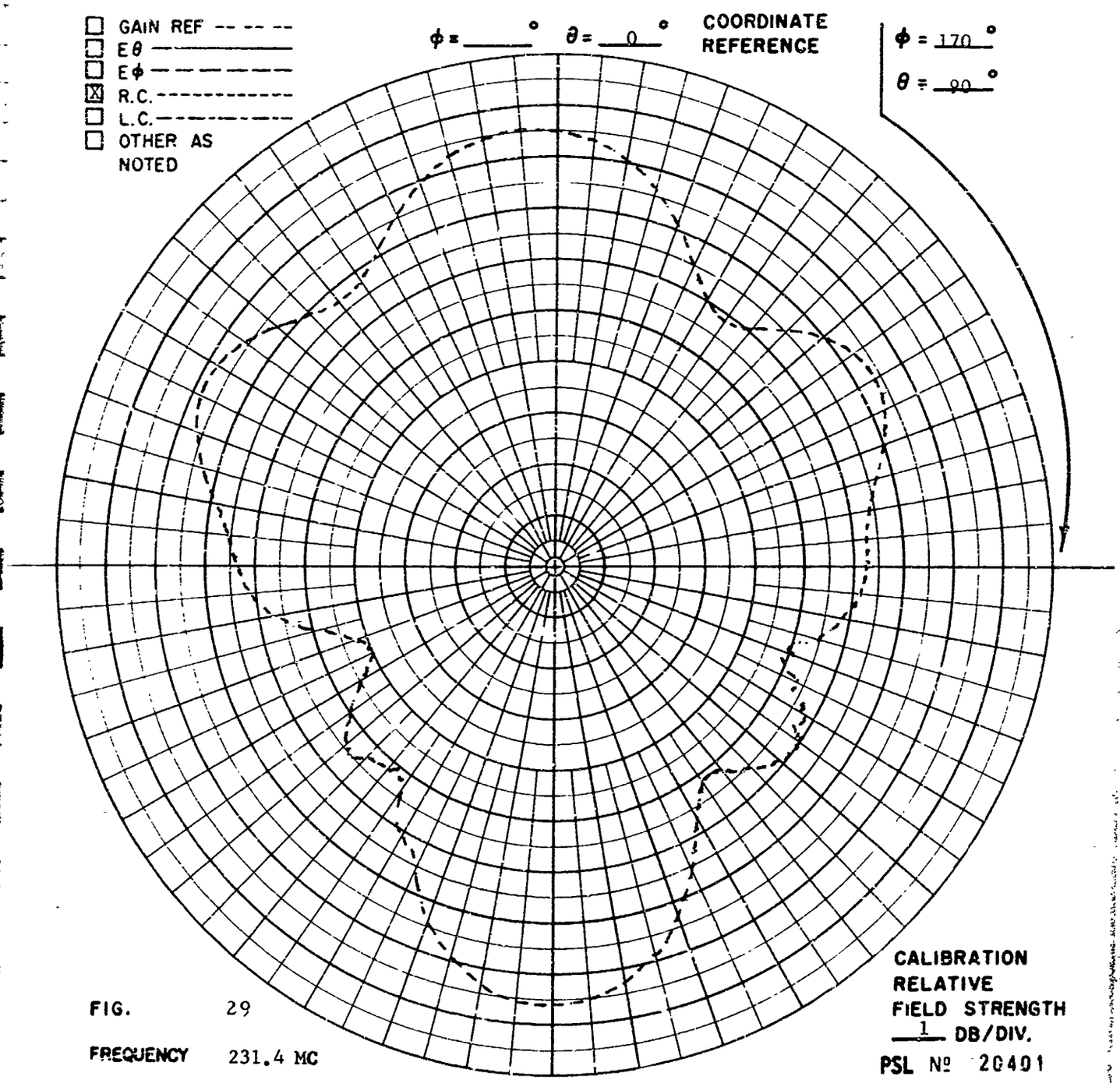


FIG. 29

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS NOSE CONE MOUNTED FOR PATTERN MEASUREMENTS.

1. ANTENNA MODEL NO: 2.041	4. NUMBER OF ELEMENTS IN THE ARRAY: Two	7. PATTERN MEASUREMENT FREQUENCY: 231.4 Mc
2. PSL RANGE REQUEST NO: 316A	5. VEHICLE MOCKUP: Javelin 12.03	8. POLARIZATION COMPONENT RECORDED: Right Circular
3. PSL PATTERN NOS. FROM 20339 TO 20401	6. MODEL SCALE: 1 : 1	9. ARRAY PHASING: 180° out of phase
10 GAIN REFERENCE The (0) db line corresponds with the gain of a half-wave Stoddard dipole		
11. REMARKS: Nose cone in place		

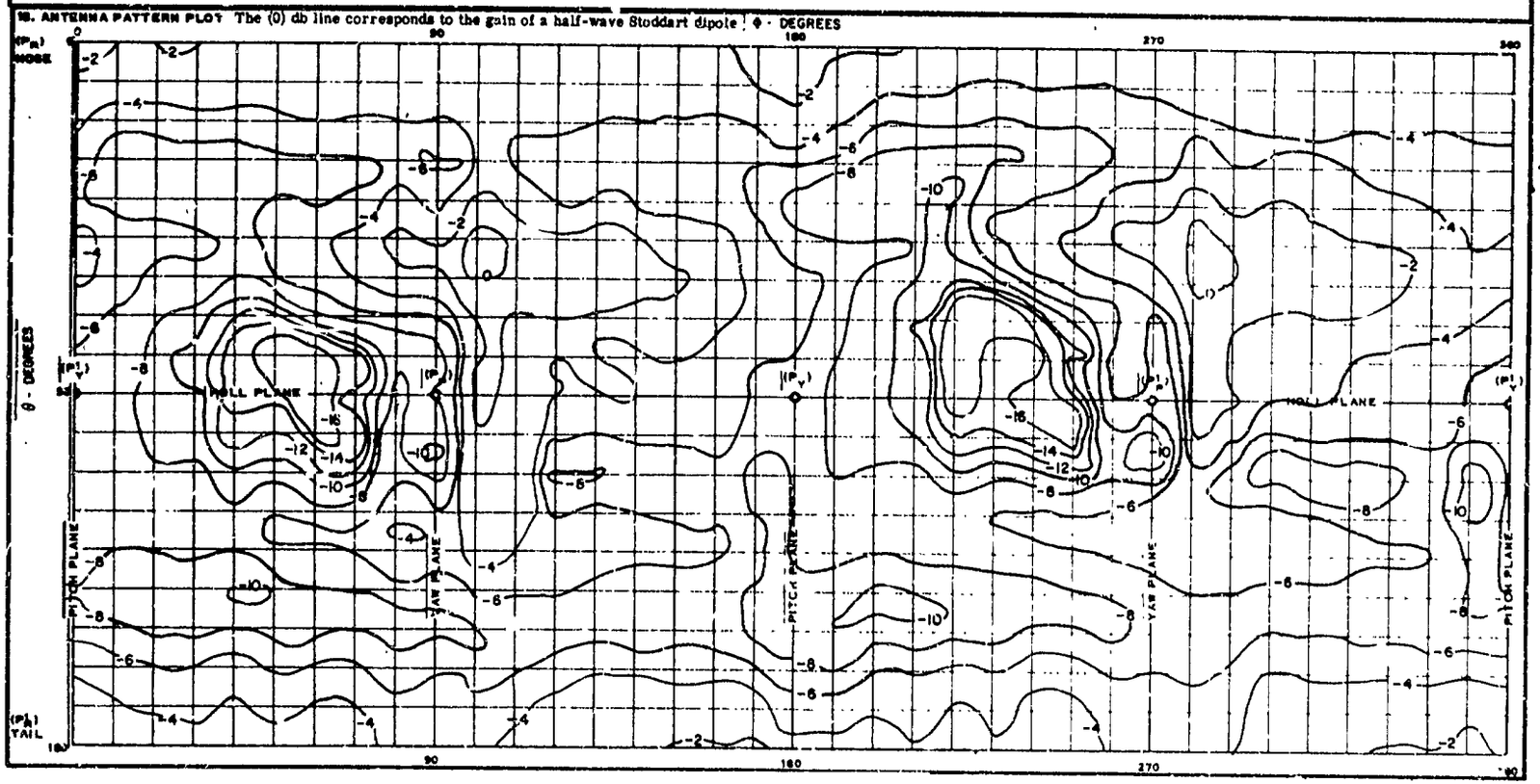


FIG. 30 - POWER CONTOUR PLOT FOR JAVELIN 12.03 WITH FIBERGLAS NOSE CONE MOUNTED

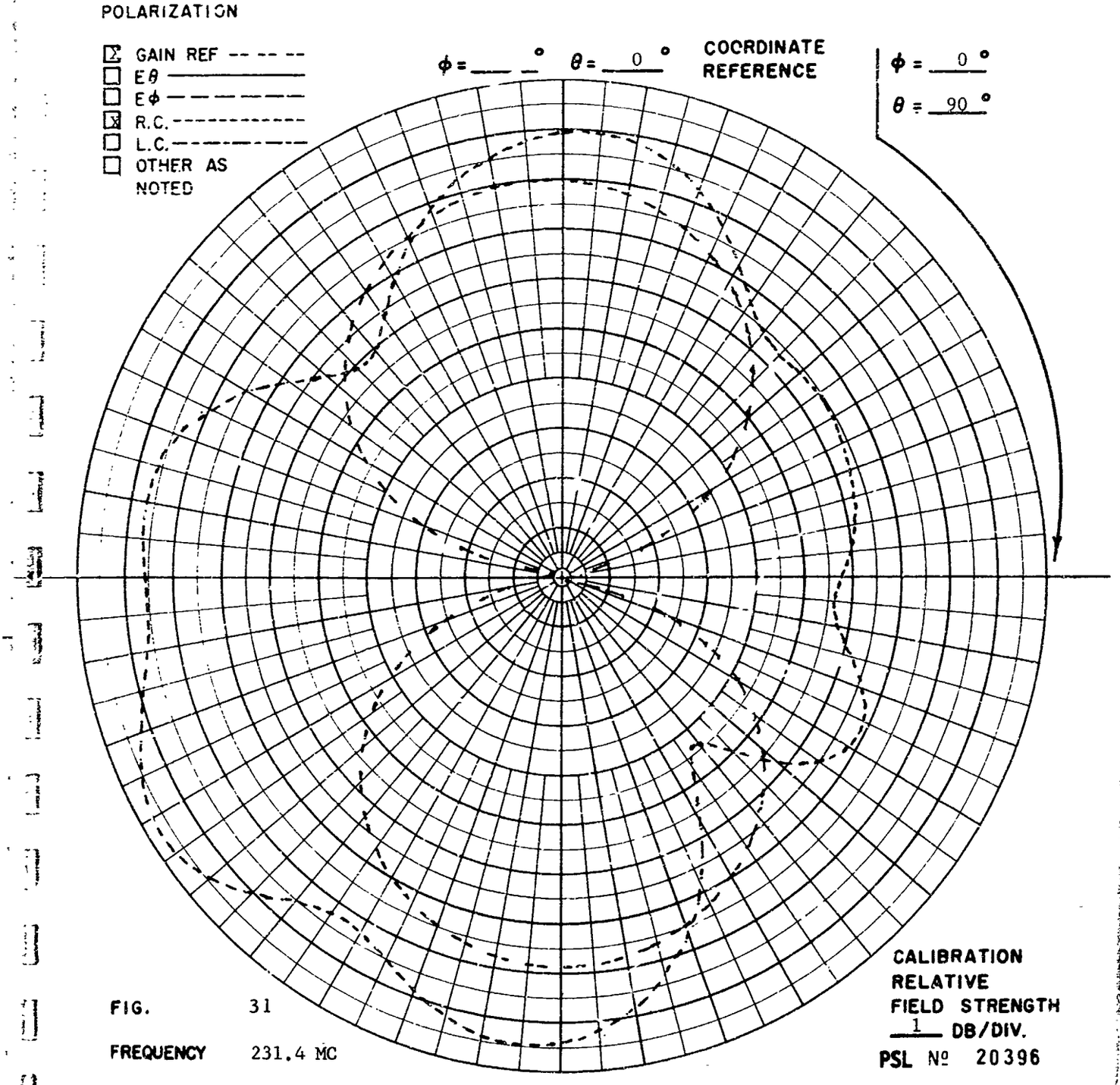


FIG. 31

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS THE GAIN AT $\theta = 180^{\circ}$, $\phi = 0^{\circ}$ IS +3 DB WITH RESPECT TO A STODDART HALF-WAVE DIPOLE.

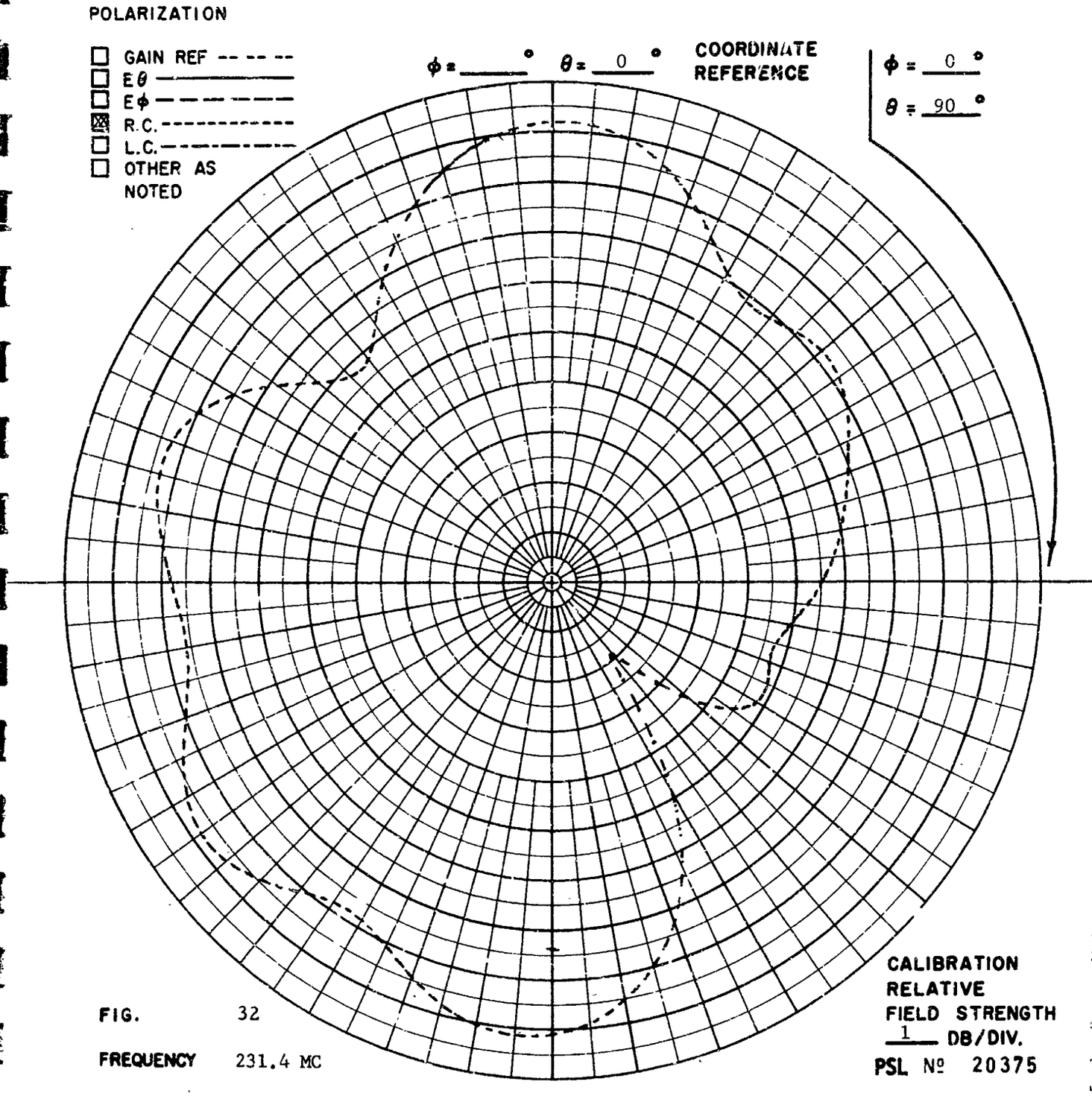


FIG. 32

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

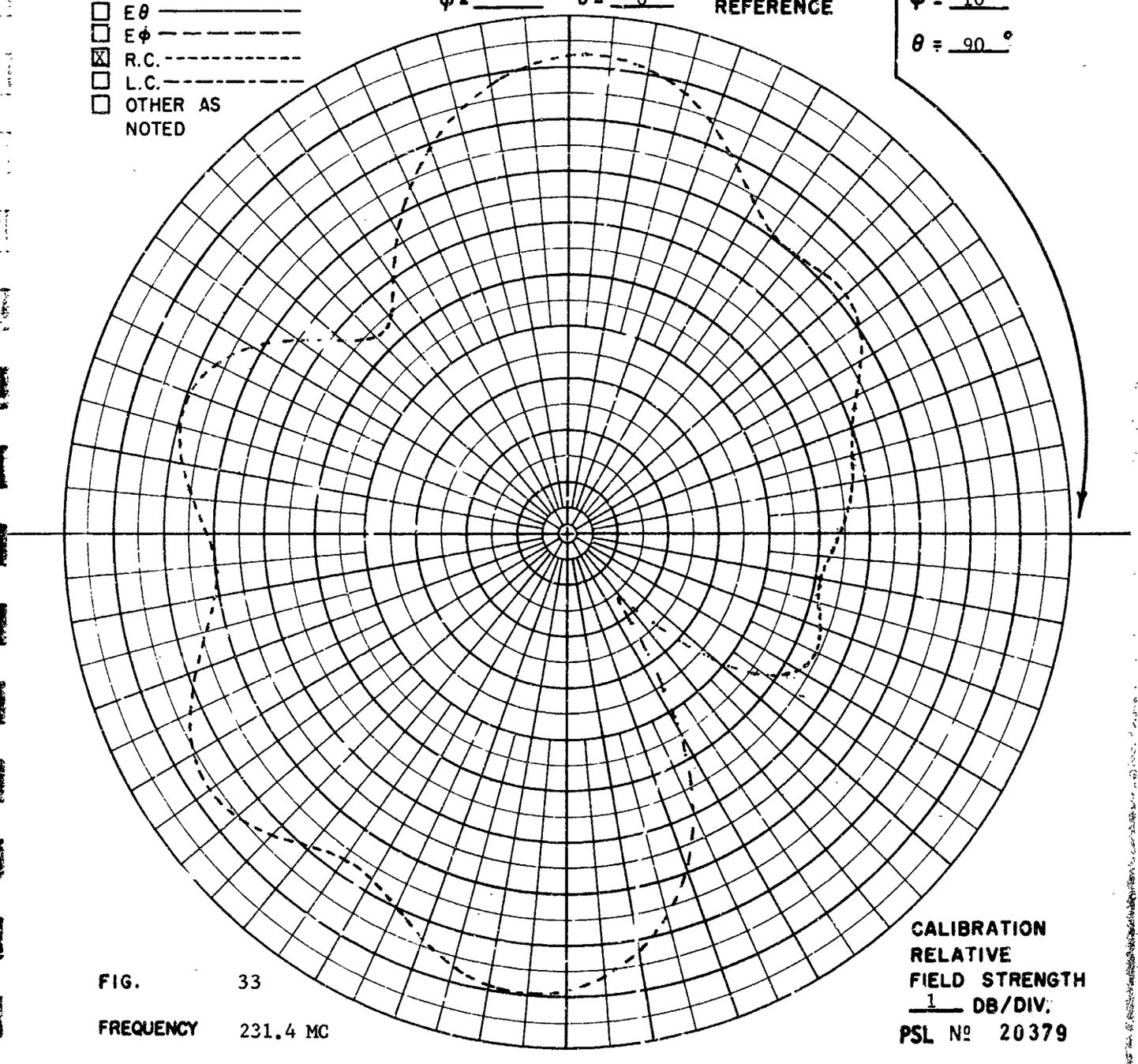
POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ————————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 10 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20379

FIG. 33

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

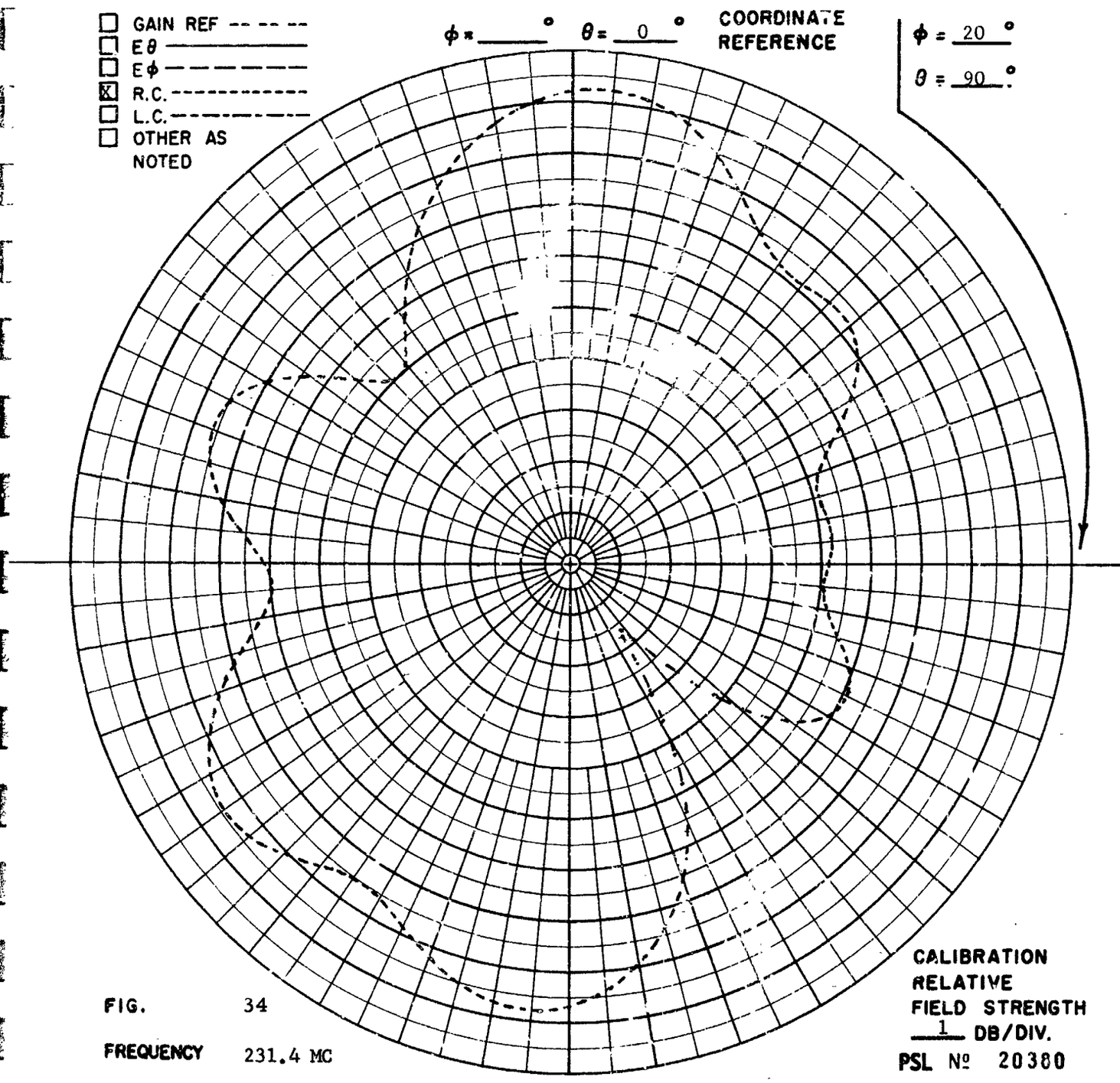


FIG. 34

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

POLARIZATION

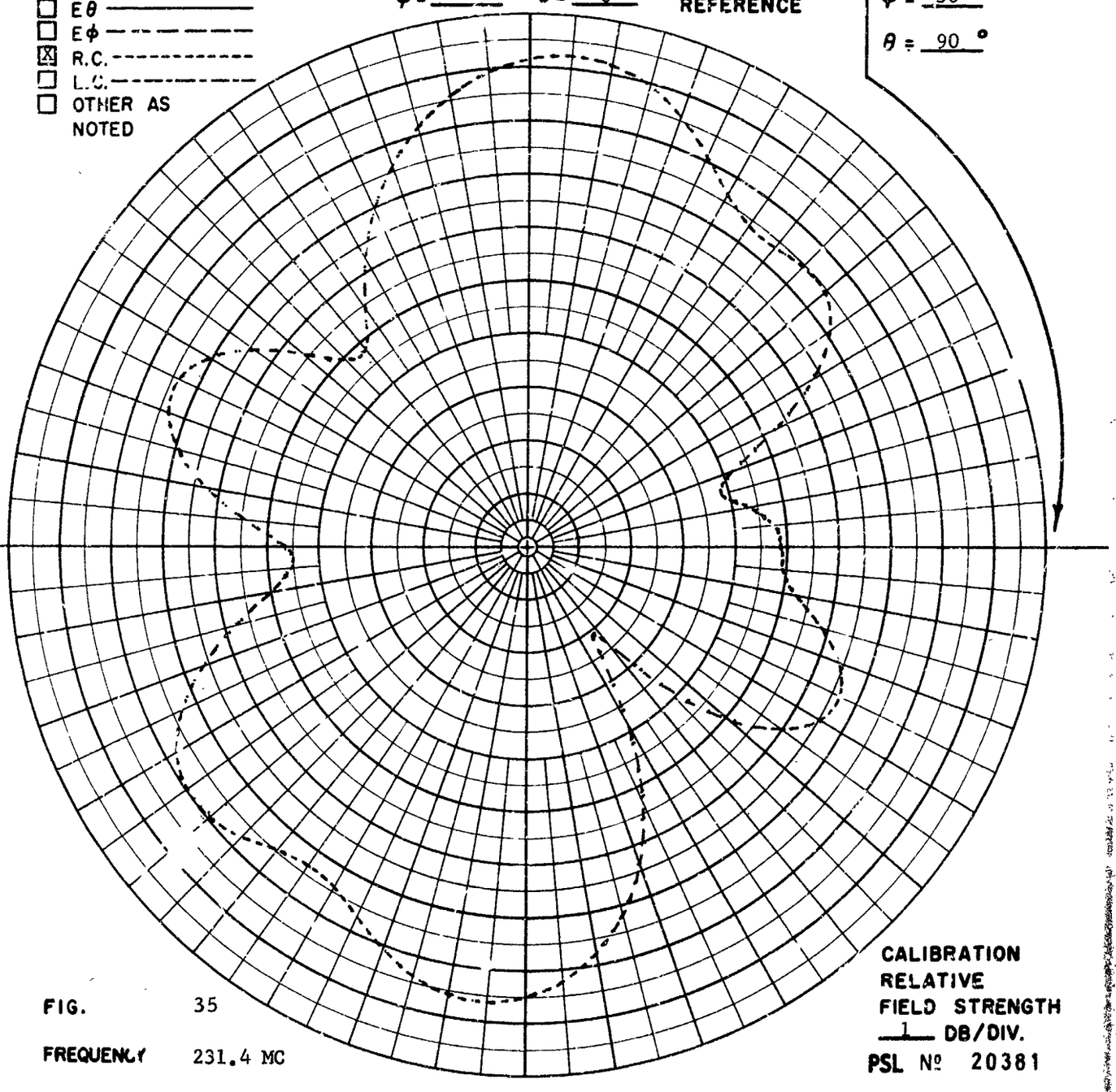
- ☐ GAIN REF -- -- --
- ☐ Eθ ——————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — · — · —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 30 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20381

FIG. 35

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

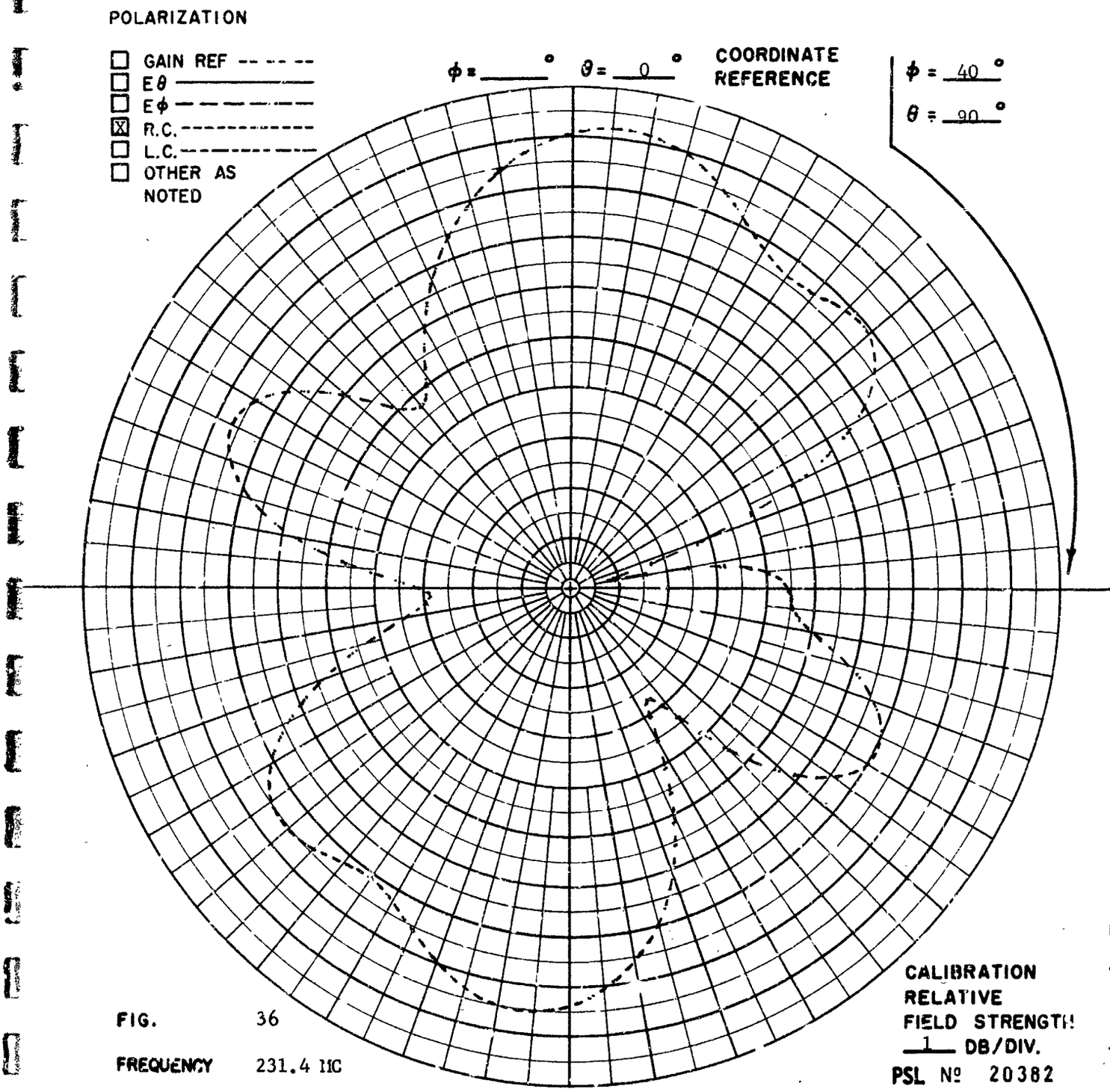


FIG. 36

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

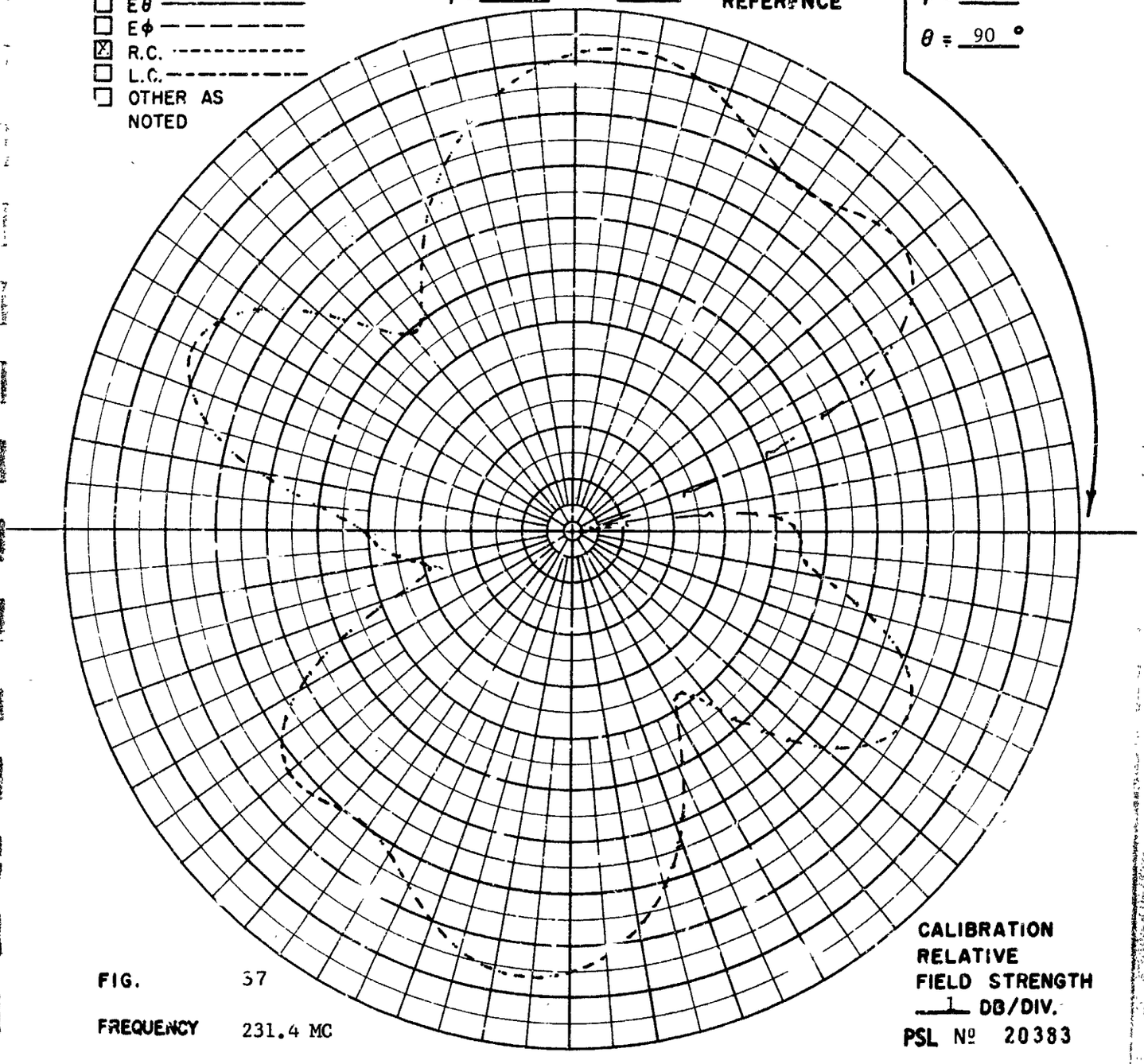
POLARIZATION

- ☐ GAIN REF - -- --
- ☐ Eθ ————————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 50 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20383

FIG. 37

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

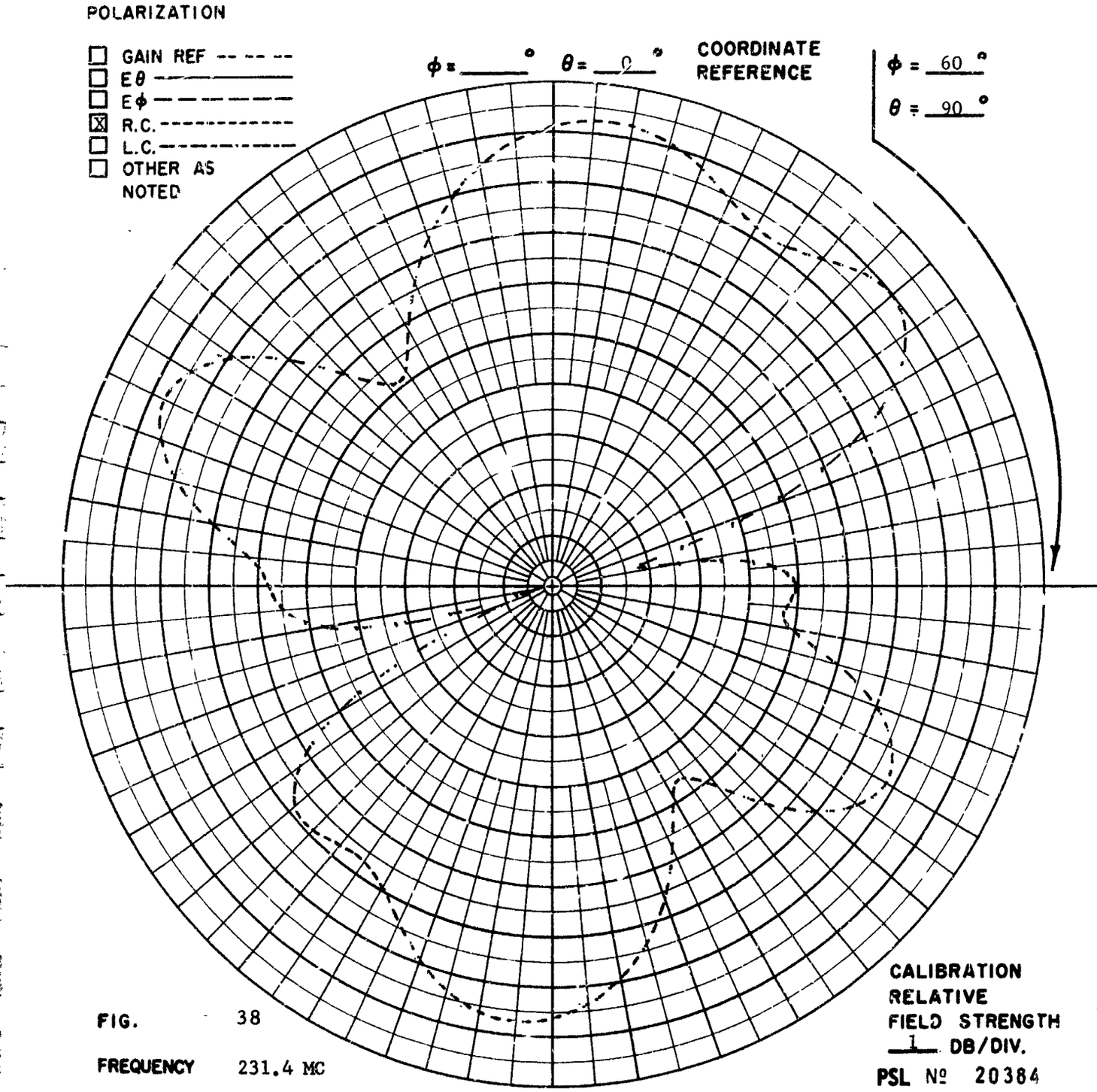


FIG. 38

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE DIRECTED, NOSE CONE REMOVED.

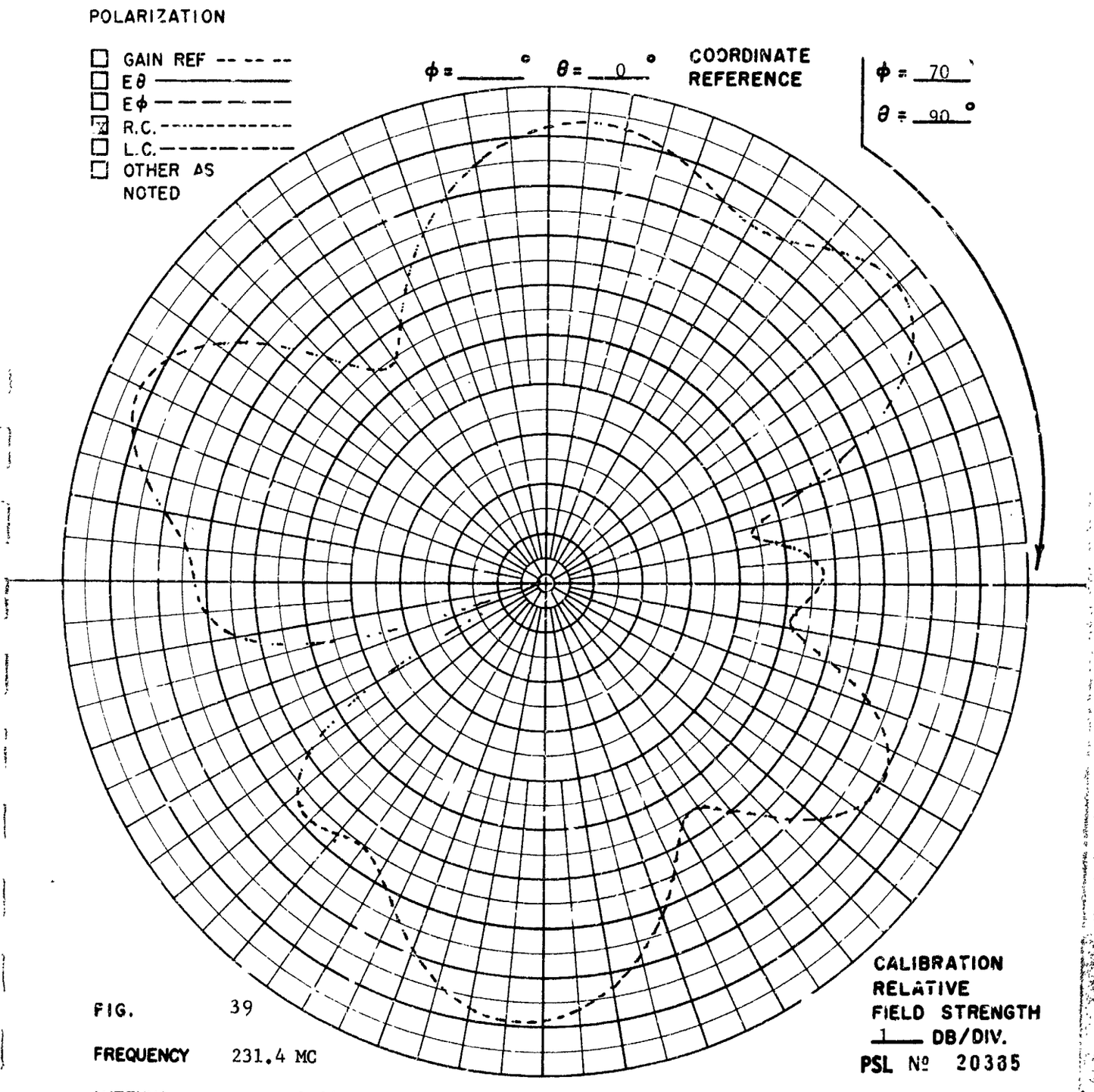


FIG. 39

FREQUENCY 231.4 MC

ANTENNA MODEL 2.0[illegible] ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTER[illegible]ED WITH PROBE ERECTED, NOSE CONE REMOVED.

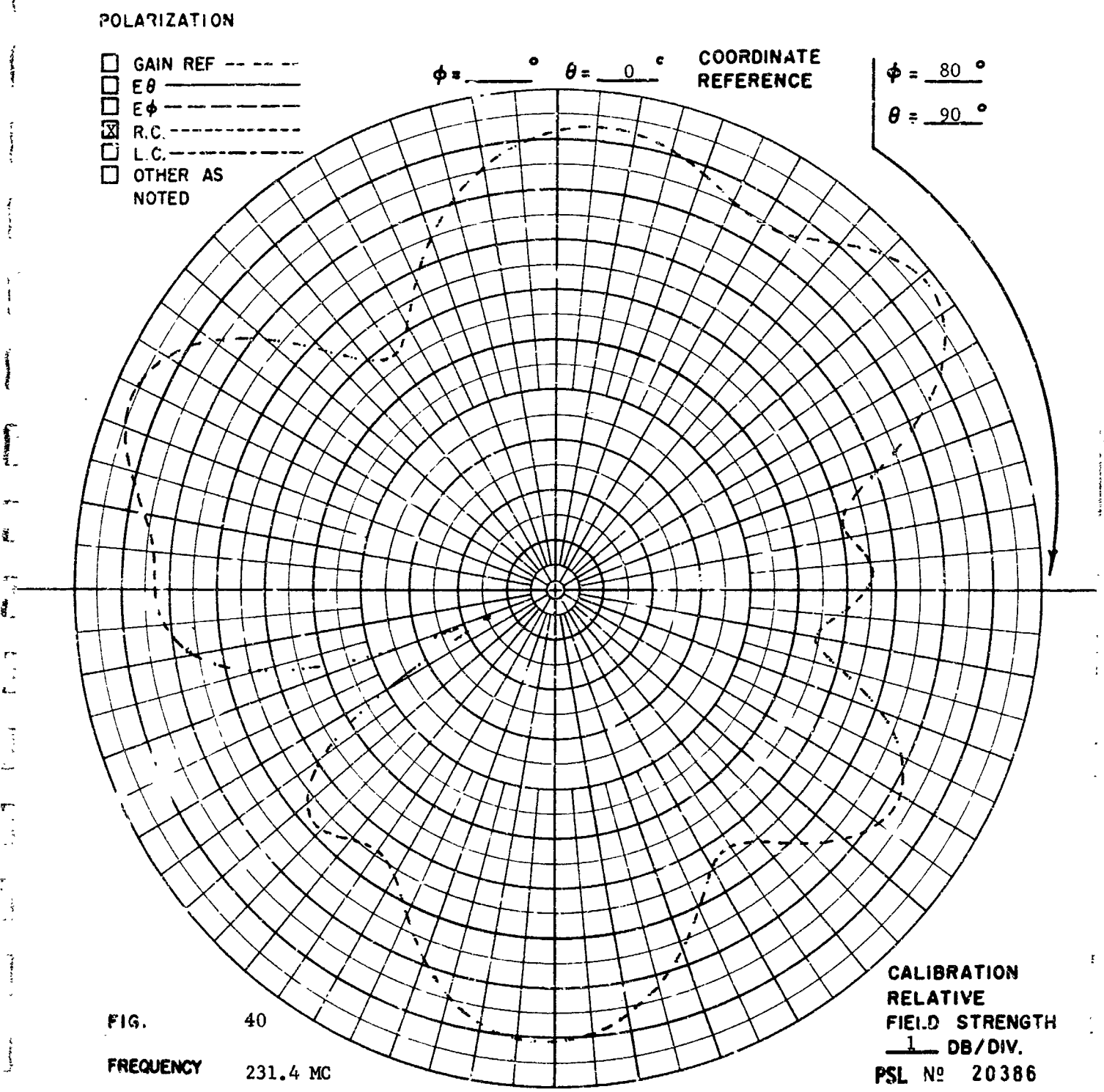


FIG. 40

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECT, NOSE CONE REMOVED.

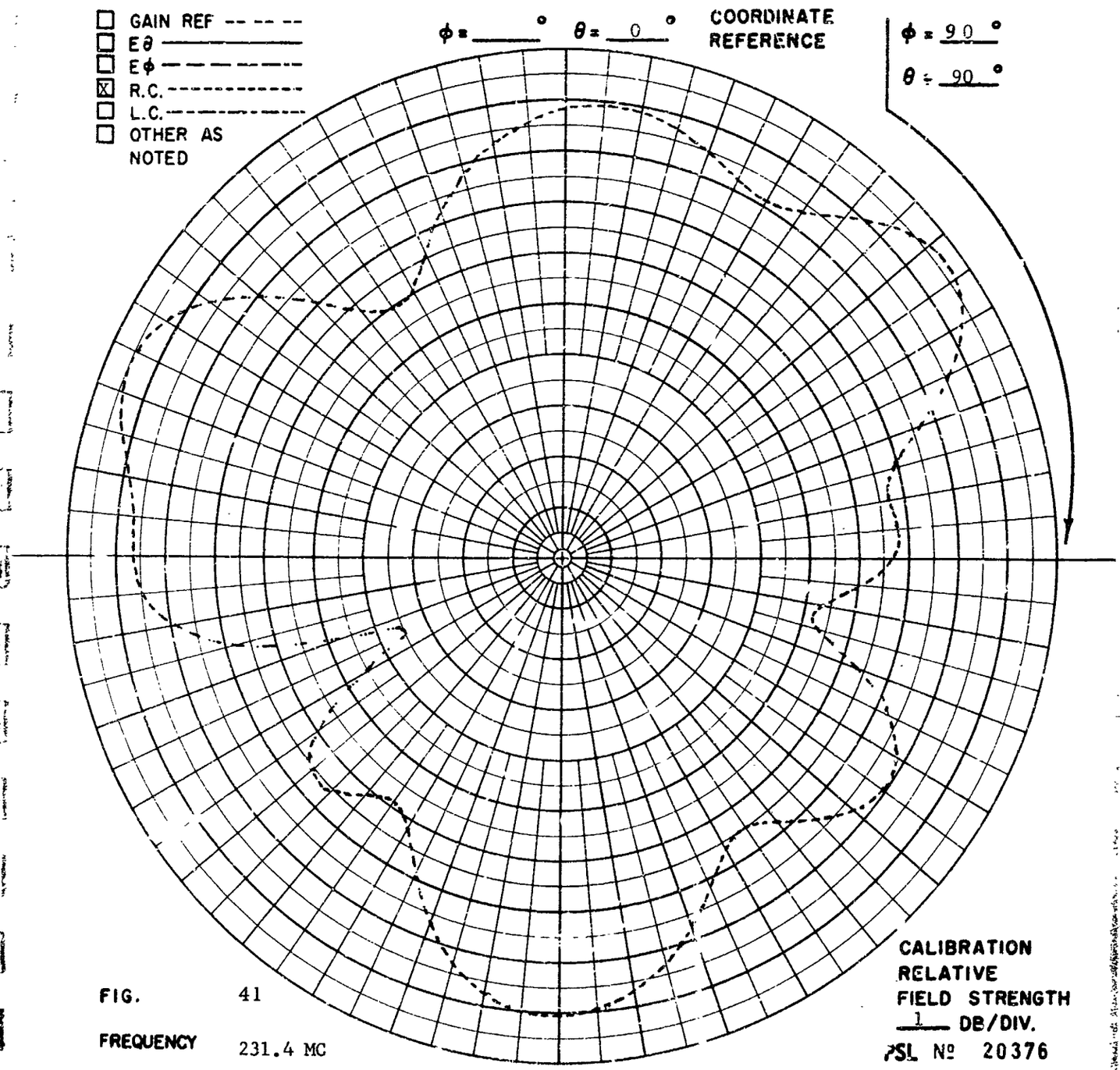


FIG. 41

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

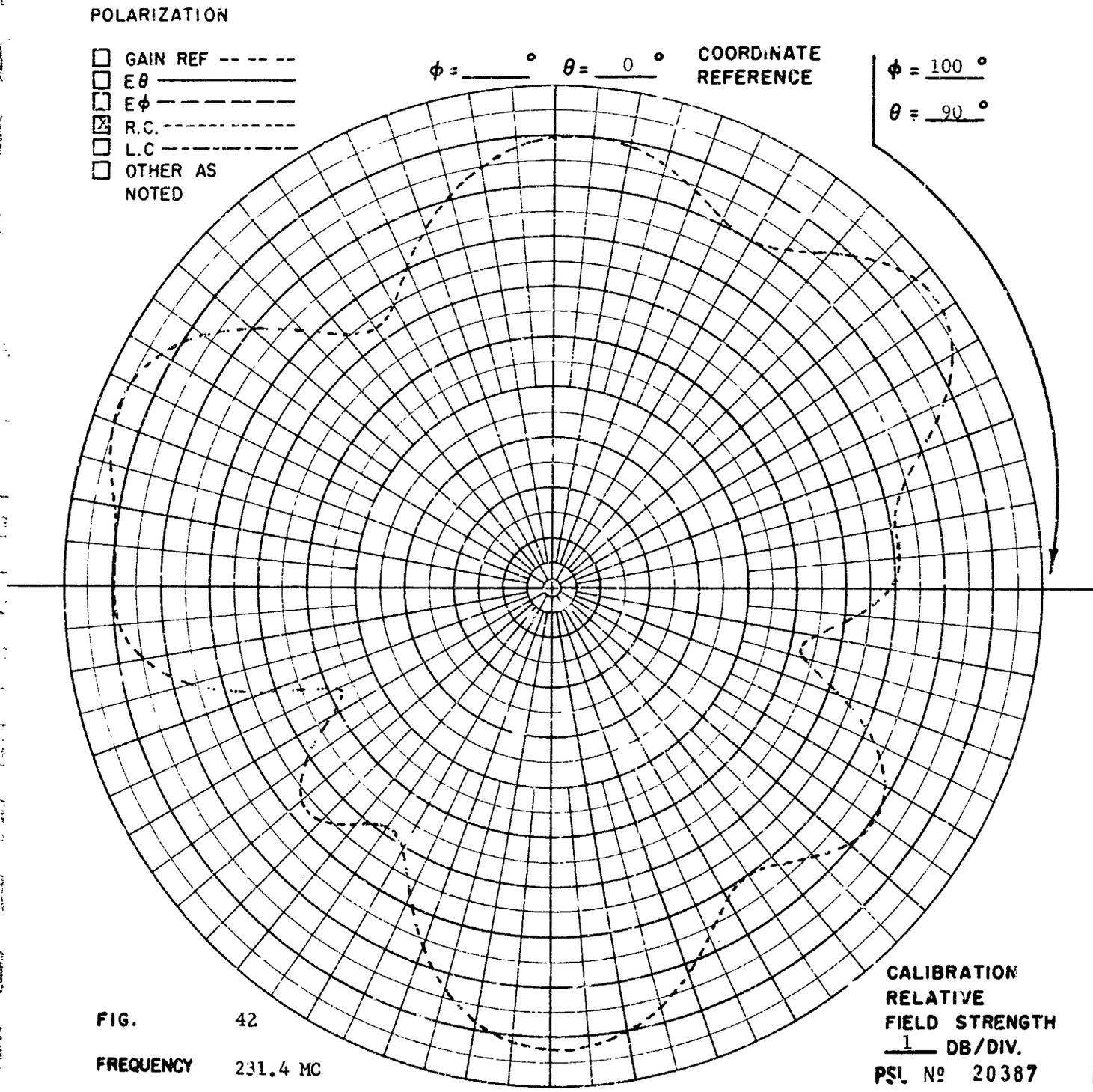


FIG. 42

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

POLARIZATION

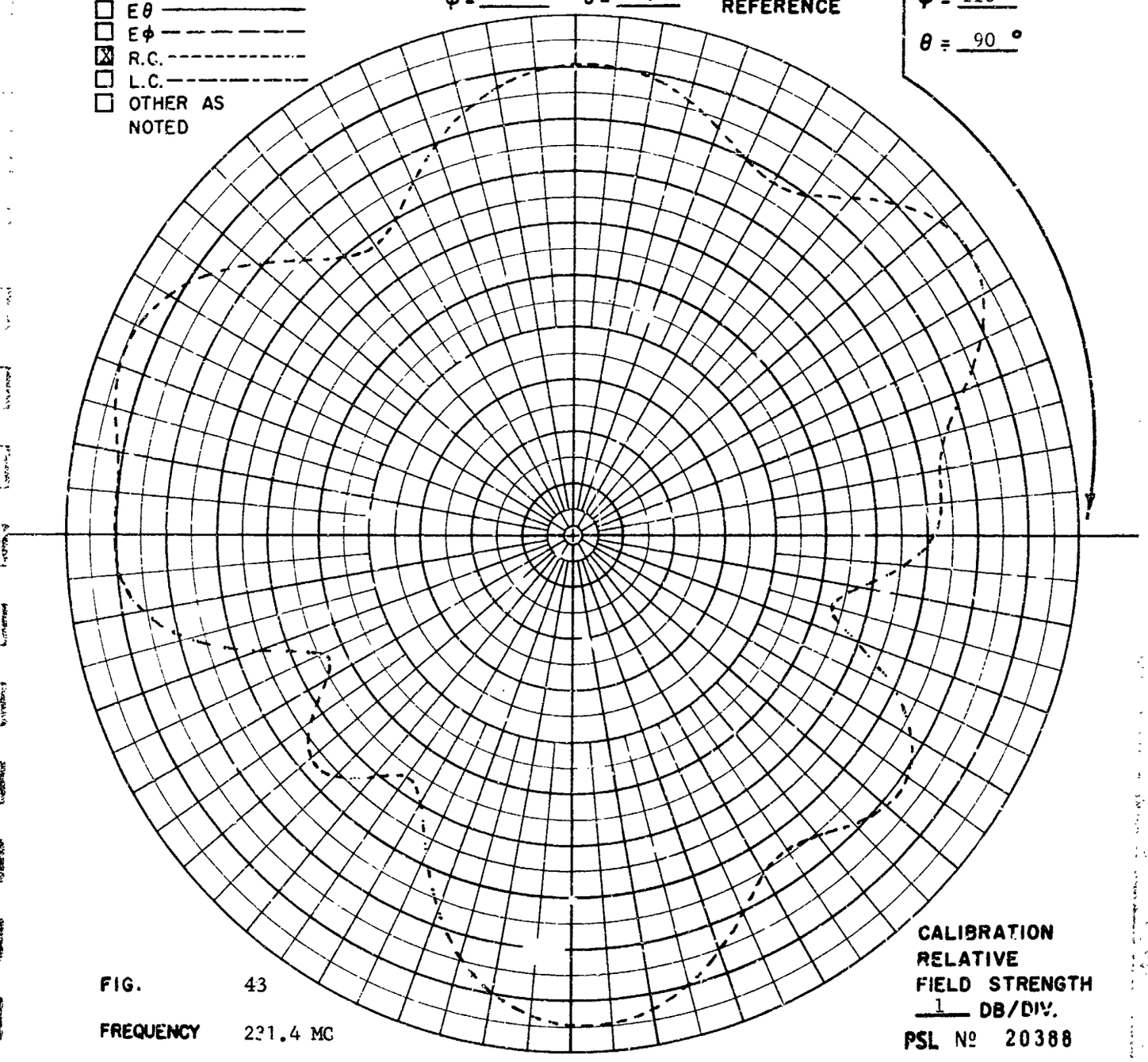
- ☐ GAIN REF -- -- --
- ☐ Eθ ——————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 °

COORDINATE REFERENCE

φ = 110 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20388

FIG. 43

FREQUENCY 221.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

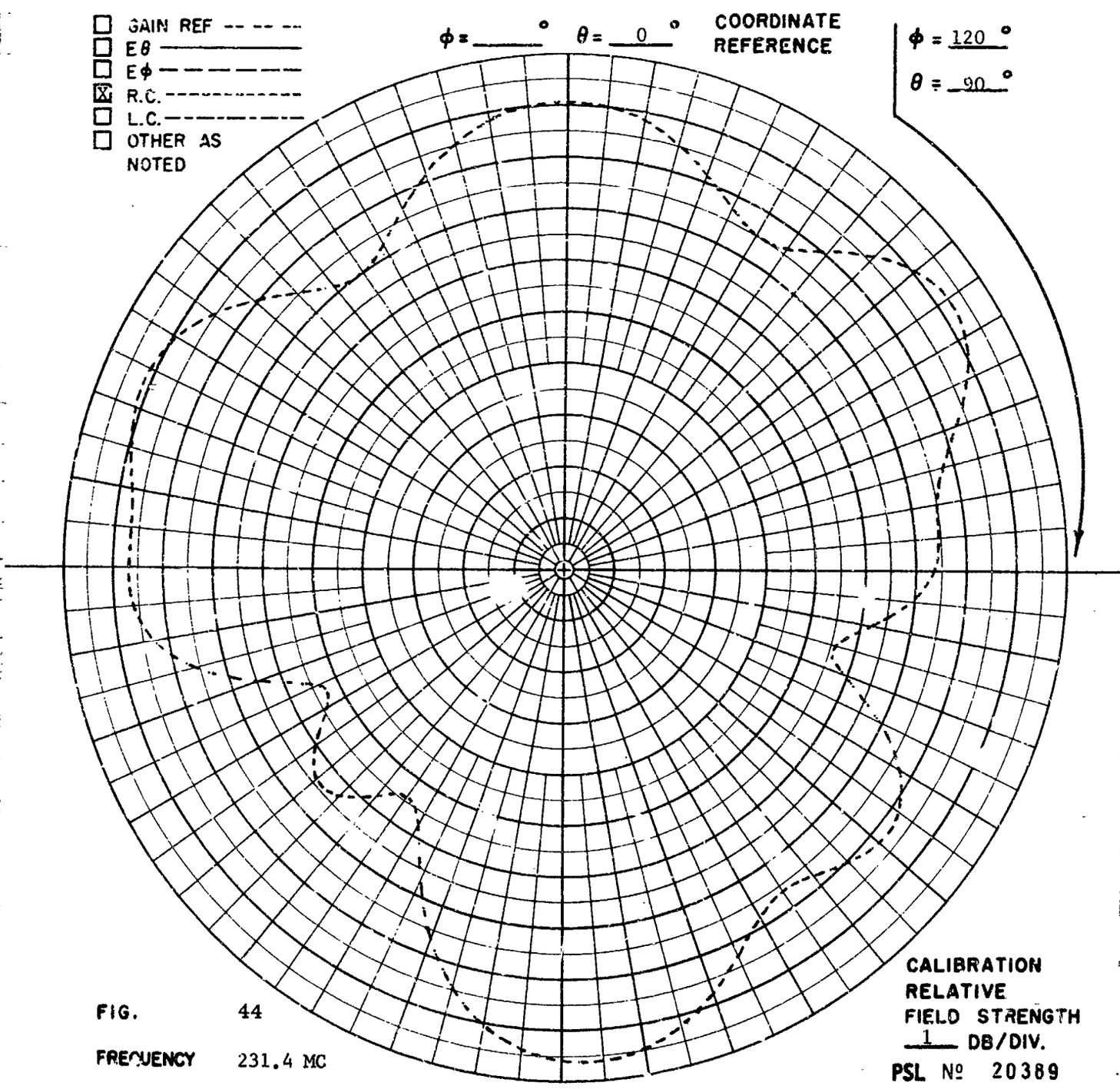


FIG. 44

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

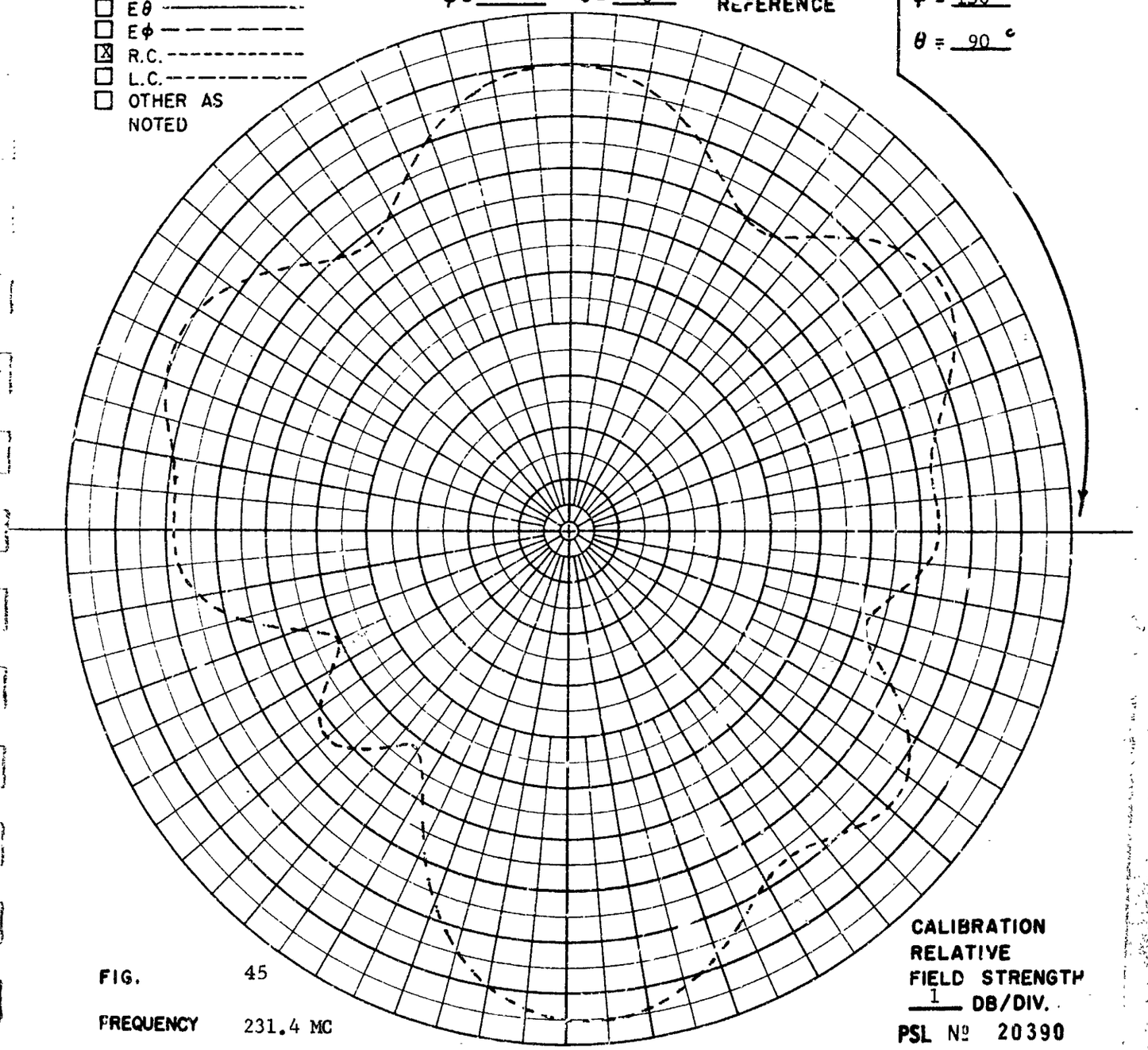
POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ————————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. — — — — —
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 130 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 20390

FIG. 45

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

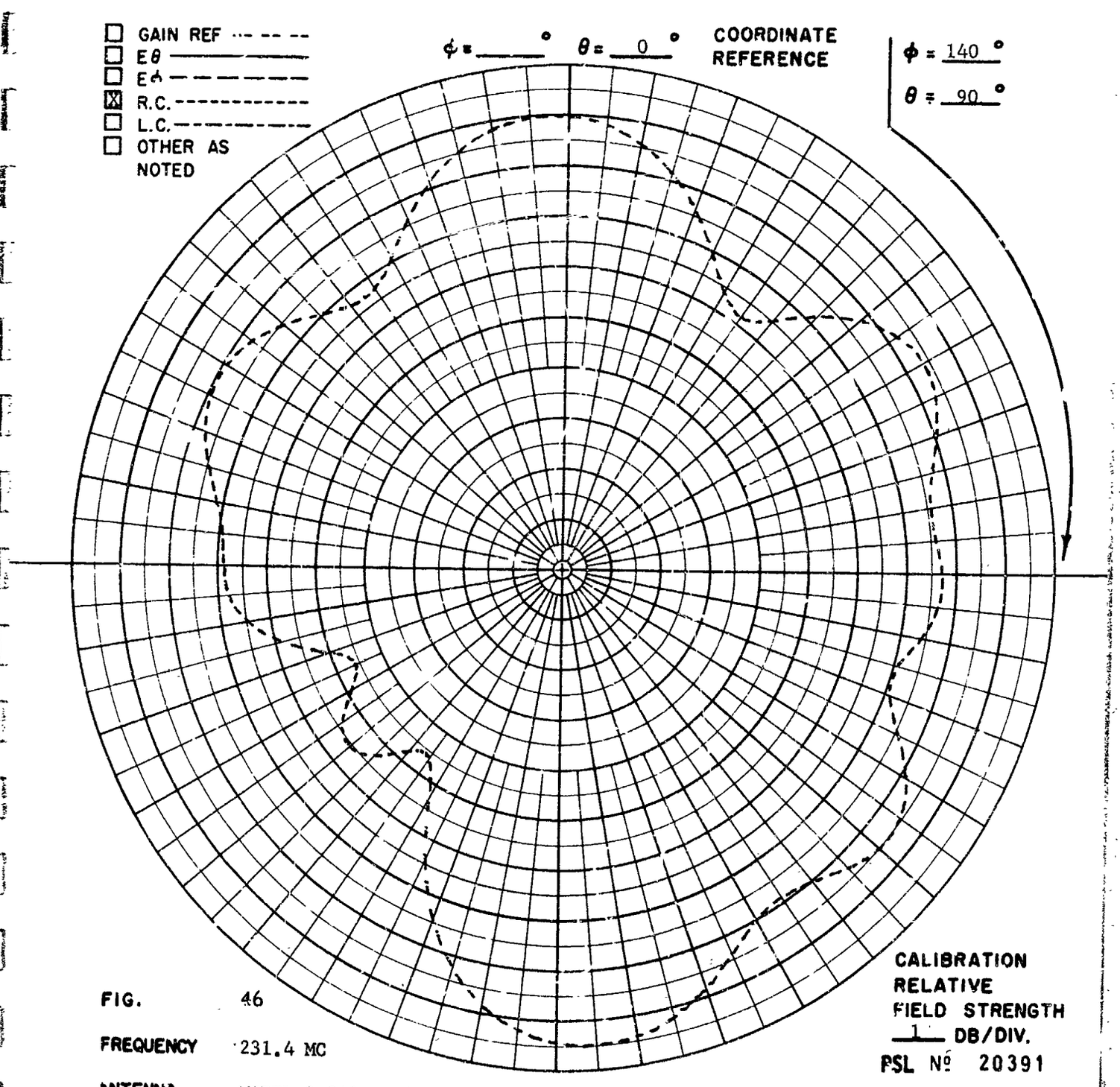


FIG. 46

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

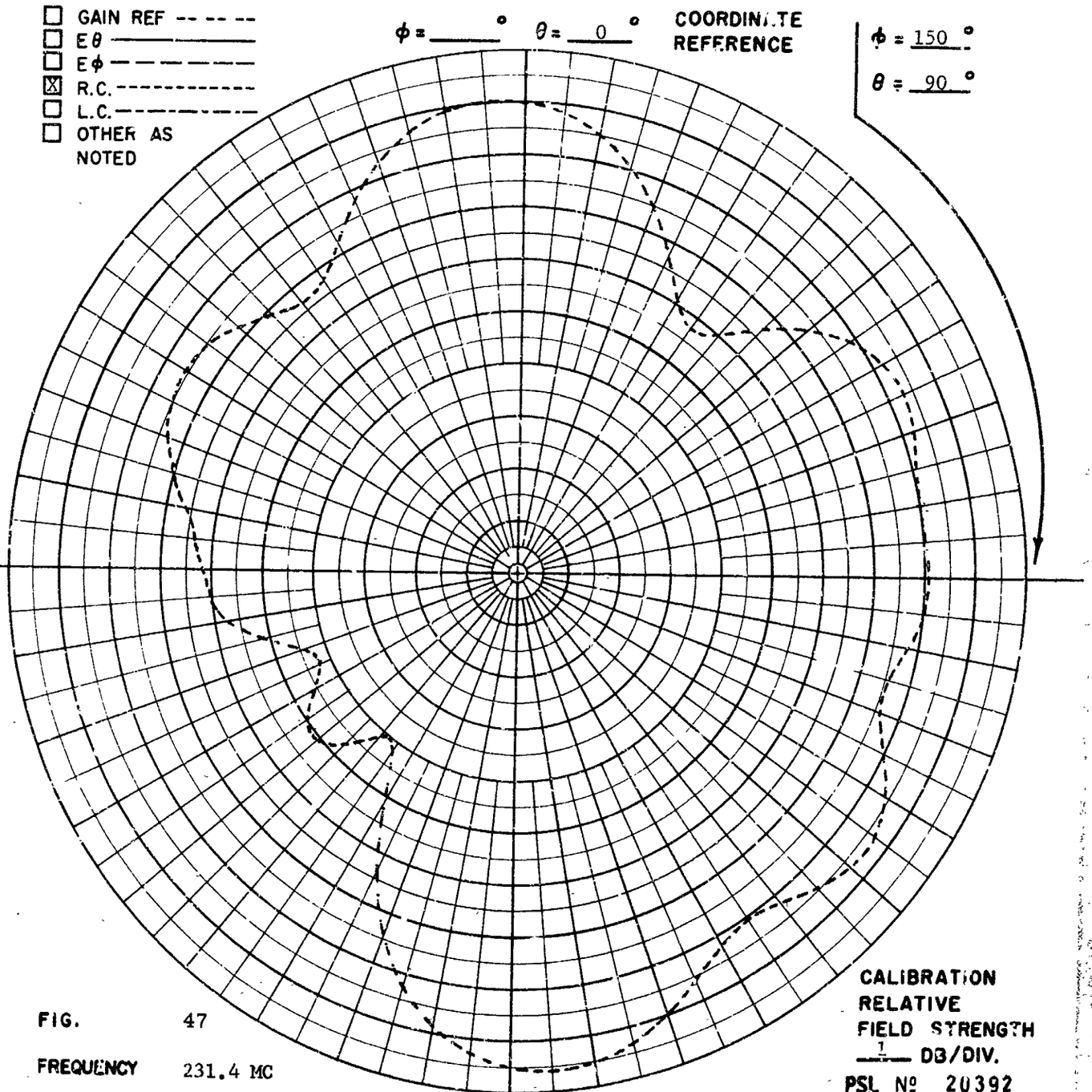


FIG. 47

FREQUENCY 231.4 MC

ANTENNA MODEL 2.C41 ON A JAVELIN 12.03 MOCKUP.

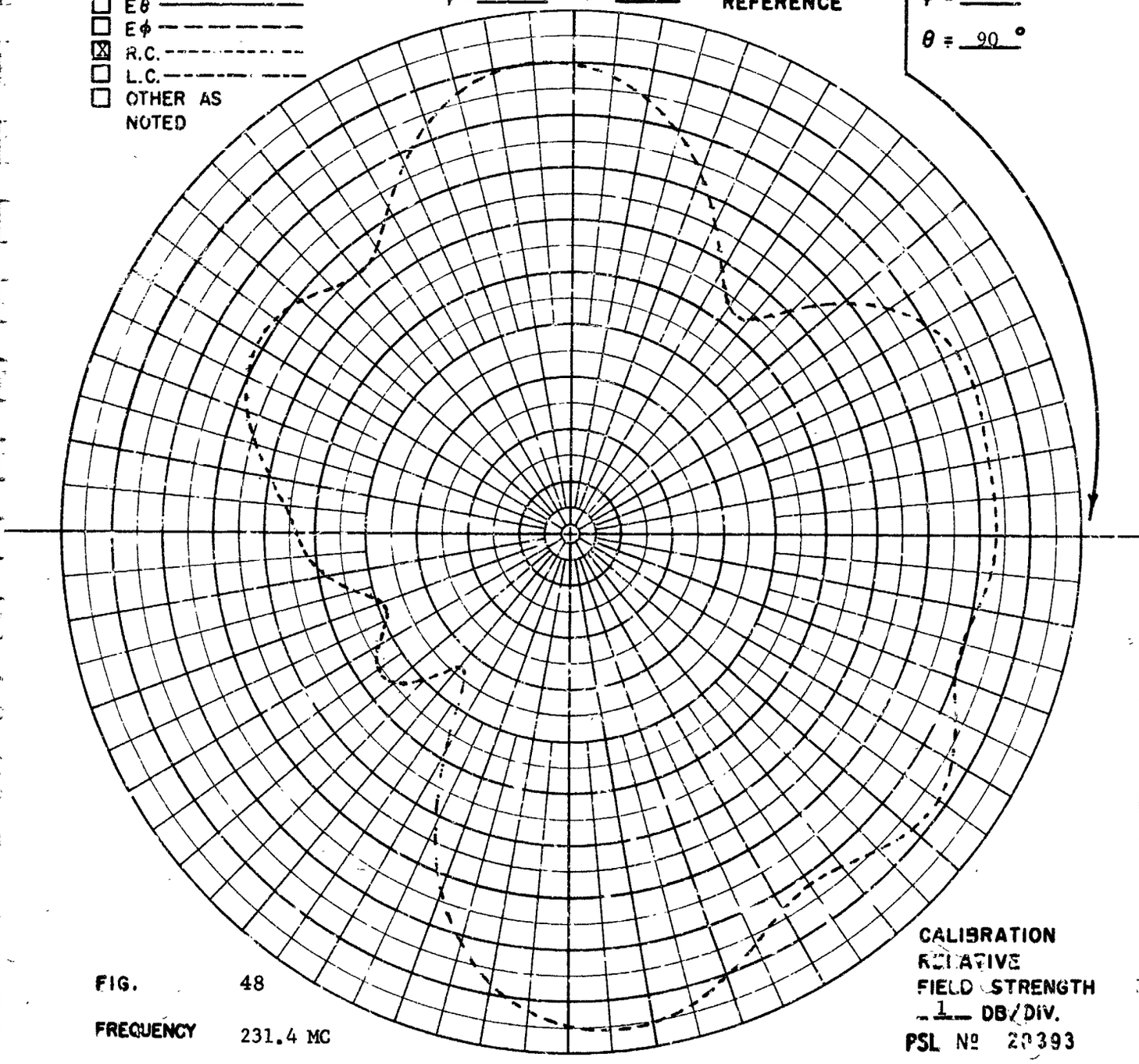
REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

POLARIZATION

- ☐ GAIN REF
- ☐ Eθ
- ☐ Eφ
- ☒ R.C.
- ☐ L.C.
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 160 °
θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20393

FIG. 48

FREQUENCY 231.4 MC

ANTENNA MODEL 2.041 ON A JAVELIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

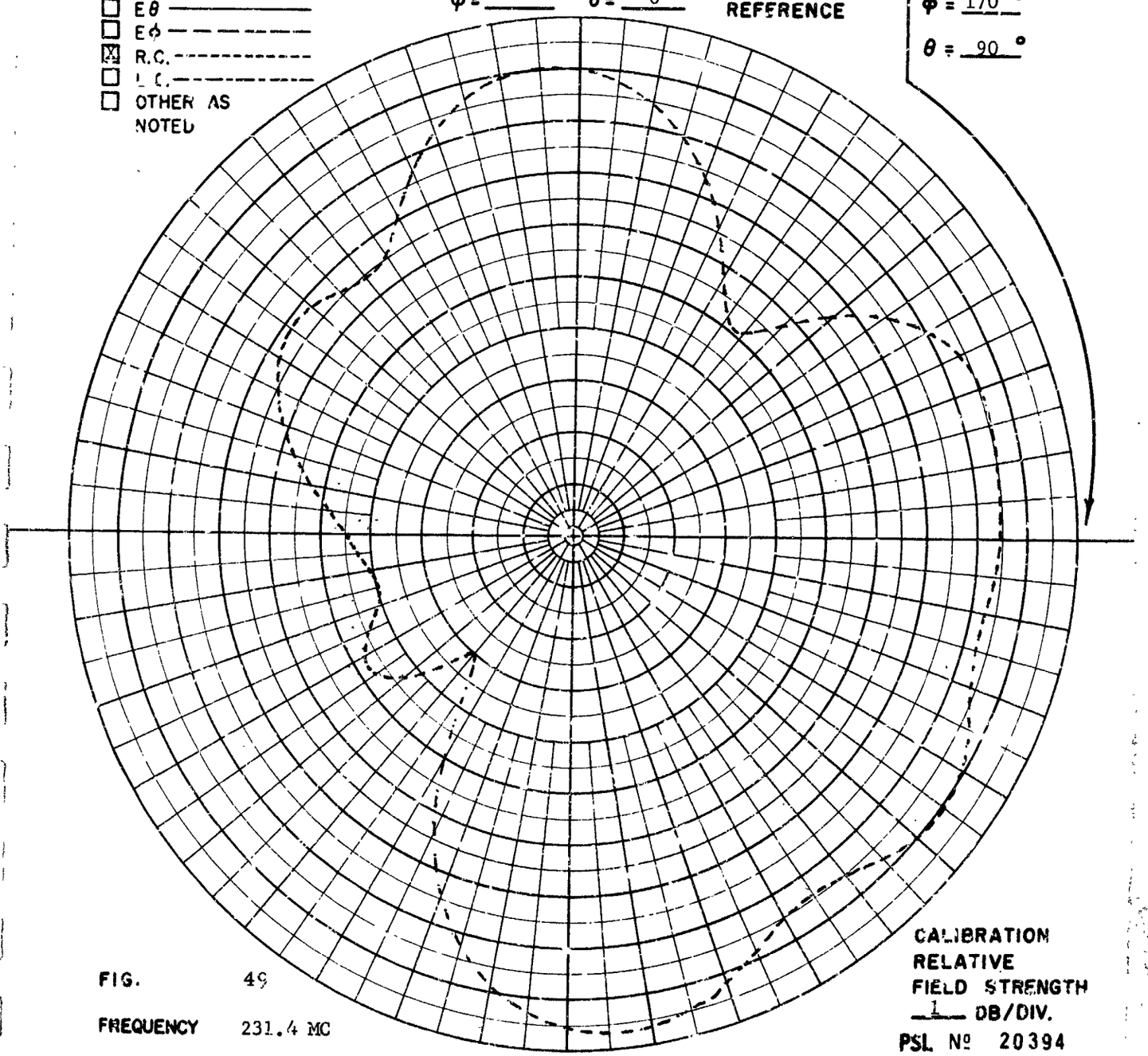
POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ——————
- ☐ Eφ — — — — —
- ☒ R.C. ----------
- ☐ L.C. ----------
- ☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 170 °

θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 20394

FIG. 49

FREQUENCY 231.4 MC

ANTENNA MODEL 2.0/1 ON A JAVEIN 12.03 MOCKUP.

REMARKS PATTERNS MEASURED WITH PROBE ERECTED, NOSE CONE REMOVED.

1. ANTENNA MODEL NO 2.041	4. NUMBER OF ELEMENTS IN THE ARRAY: Two	7. PATTERN MEASUREMENT FREQUENCY: 231.4 Mc
2. PSL RANGE REQUEST NO 316B	5. VEHICLE MOCKUP: Javelin 12.03	8. POLARIZATION COMPONENT RECORDED: Right Circular
3. PSL PATTERN NOS. FROM 20375 TO 20386	6. MODEL SCALE: 1 : 1	9. ARRAY PHASING: 180° out of phase
10. GAIN REFERENCE: The (0) db line corresponds with the gain of the half-wave Stoddard dipole		
11. REMARKS: Without nose cone, with probe		

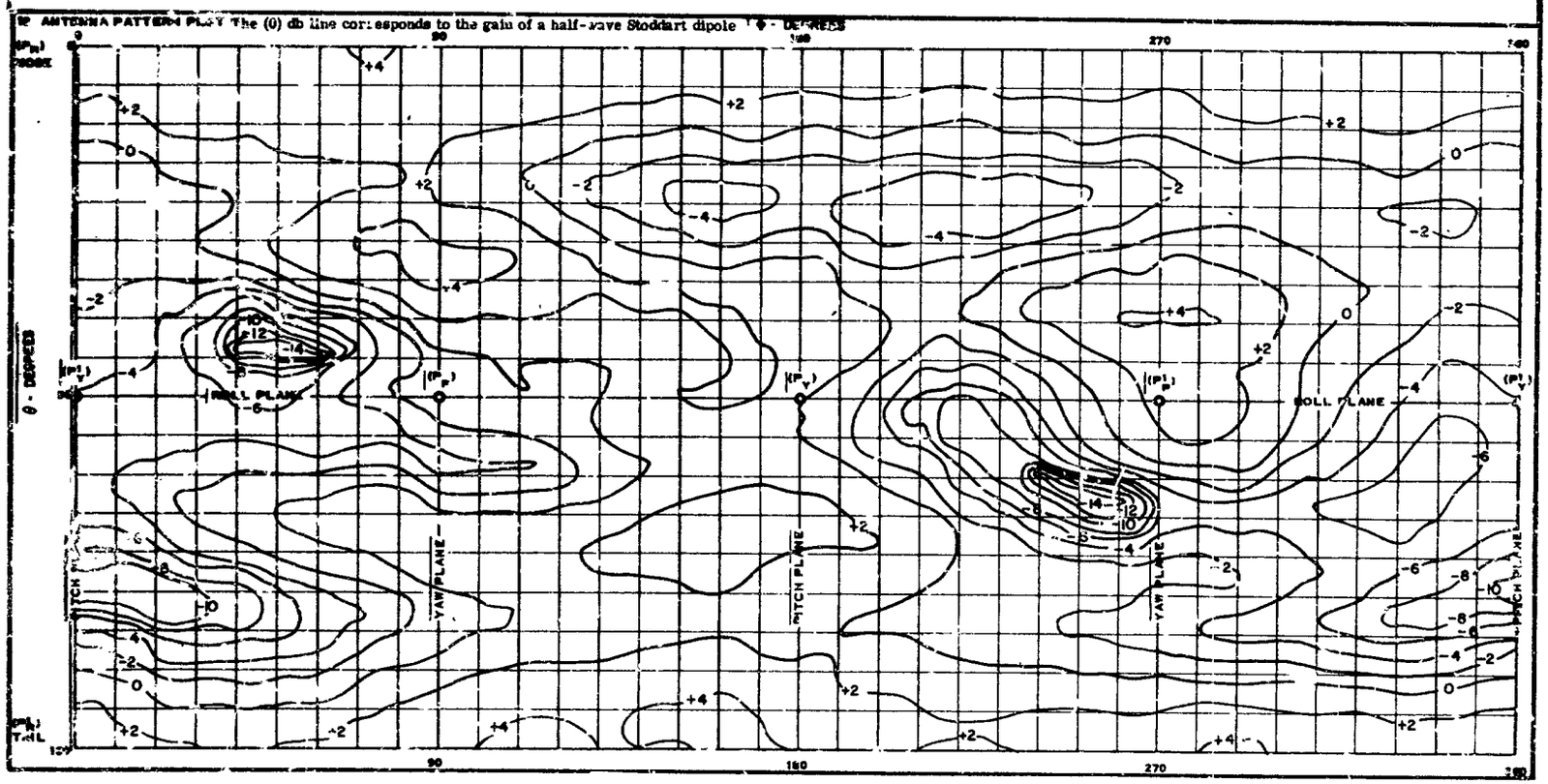


FIG. 50 - POWER CONTOUR PLOT FOR JAVELIN 12.03 WITH FIBERGLAS NOSE CONE REMOVED AND PROBE ERECTED

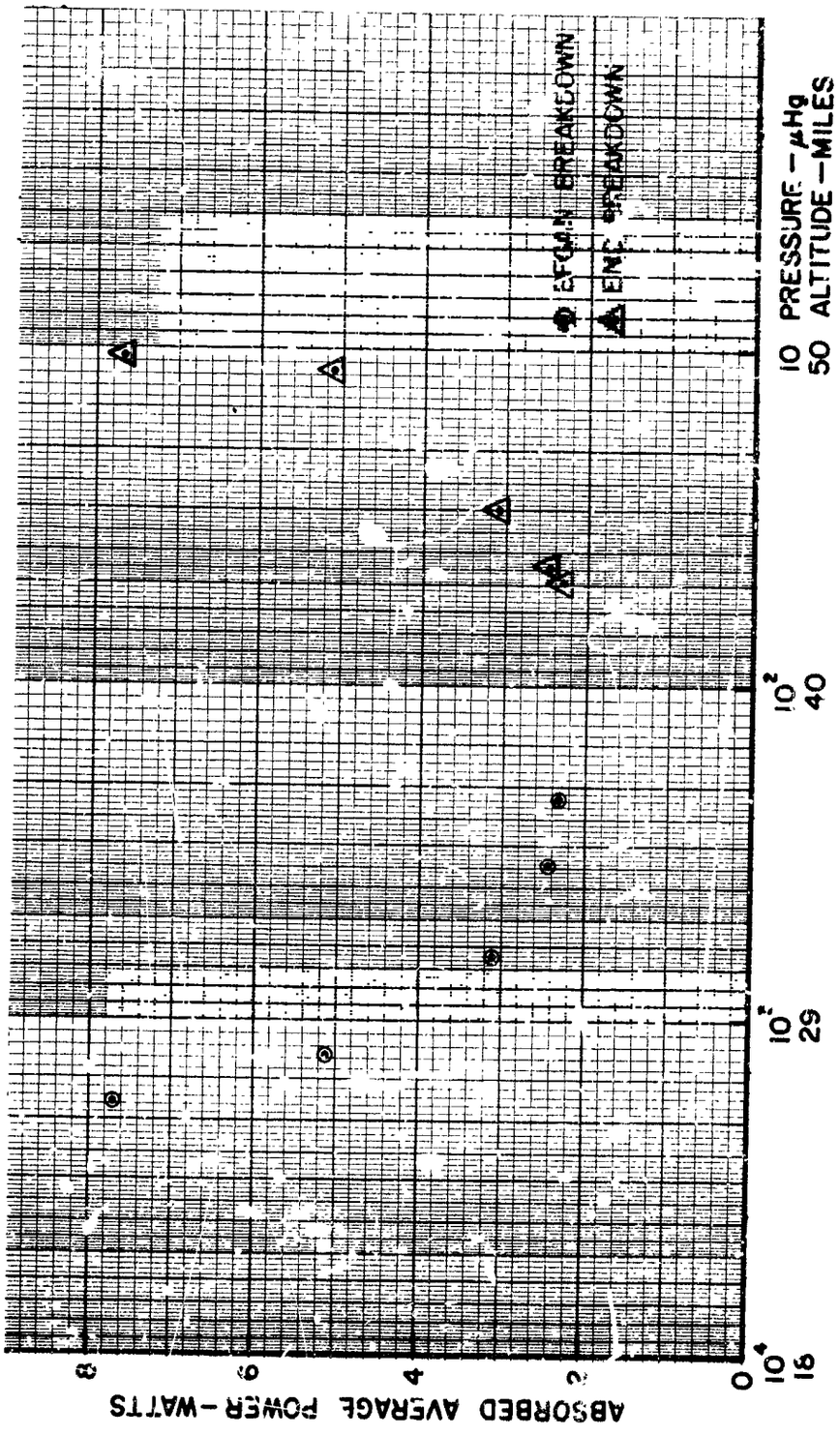


FIG. 51 - RADIO FREQUENCY BREAKDOWN CURVE

BIBLIOGRAPHY

1. Henry, D. G., and H. W. Haas, Design of Model 2.040 and 2.041 Quadraloop Antennas, September 1963, Contract No. AF 19(628)3229